A review of the proposed approach for the threatened species licence as part of the coastal IFOAs

Final Report

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Report to the NSW Environment Protection Authority, Forestry Corporation and Department of Primary Industries (Fisheries)

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Front page photograph: A large tree in New England Blackbutt forest in Marengo State Forest, NSW, Sarah Munks, Forest Practices Board.

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Contents

A review of the proposed approach for the threatened species licence as part of the coastal IFOAs - Final Report

Summary

- This report has been prepared by the Tasmanian Forest Practices Authority for the NSW Environment Protection Authority, Forestry Corporation and Department of Primary Industries (Fisheries). It builds on the preliminary report produced to meet Milestone 1 (Munks et al. 2014) and provides a response to the queries raised by the NSW team in relation to the conditions in the revised TSL (Milestone 2 of the contract brief, Appendix A).

- In general the proposed TSL licence will contribute to the overarching goals and sub-objectives identified in the literature as important for the conservation of forest biodiversity in production forest areas and are consistent with the multi-spatial scale approach taken in other jurisdictions. Some areas for further consideration, to make the approach more effective in the current context include, the setting of overarching guiding principles to take account of the trade-off between conservation and economic outcomes, development of clear and measurable outcomes, development of comprehensive guidelines and a program of training and awareness raising for those involved in implementation and monitoring, and development of a monitoring program and process for continual improvement.

- The results of our review indicate that the combined conditions, should meet the desired outcomes. However, some gaps are highlighted. Areas that need further work are measures for dispersing harvesting (in particular the maximum harvesting threshold), the size and composition of the habitat clumps, ways to minimise edge effects impacting on excluded areas and measures for sensitive species not adequately covered by the general conditions.

- Specific responses to queries raise by the NSW team are -

Topic	Query	Response
General approach – the overall licence concept	What are the gaps?	Conditions for • post-harvest regeneration of habitat, • the design and management of the road network and stream crossings to take into account impact on species, in-stream and riparian and hydrological processes, • the management of pests, disease and genetic pollution, • reduction of edge effects (e.g. low intensity silviculture in a zone buffering reserves or sensitive species habitat), • forest remnants of high conservation value, • maintenance of soil fertility and structure, • harvest dispersal in time and space. Some of these may, however, be covered by the general conditions in the environmental protection licence (EPL) and the fisheries licence (FL). The approach proposed through the TSL will have only limited effectiveness in terms of managing seral stage structure.

Topic	Query	Response
		One other important gap was the need for a clear 'outcome' in the TSL for continual improvement (adaptive management).
	What aspects of the approach may be hard/ problematic?	Dealing with conflicting outcomes. Balancing flexibility in how the outcomes might be achieved whilst still providing certainty in terms of expected compliance outcomes.
	In what way could the approach be improved / adapted to meet the overall goal?	Training, guidance material and procedures to enable flexibility whilst also ensuring enforceability. Structuring the outcomes using the SMART model. Taking monitoring into account when developing the outcomes, conditions and protocols.
Local landscape conditions	Is 1500 ha an appropriate scale for considering local landscape scale objectives?	1500 ha is a reasonable scale for addressing many aspects of the local landscape. However, it will be important to do a 'gap' analysis in the management area to ensure the landscape goals of heterogeneity and connectivity are being achieved. This scale may not be appropriate for ensuring spatial and temporal dispersal of harvest operations.
	Is this size meaningful ecologically? Is this appropriate for management? Definition of landscape – what has been done elsewhere?	1500 ha is larger than the home range, and potentially even the entire range, of some species. Therefore this scale is more suited to ensuring 'landscape' or 'mid-scale' management is achieved. This is larger than the scale used in many areas, but there is increasing recognition of the importance of managing landscapes.
	Are discreet local landscapes the way to go (group of compartments)? Or should it be a roving window (each harvestable areas and surrounding area)?	Both fixed and roving local landscape methods have advantages and disadvantages. Fixed landscapes, however, may be most practical when assessing minimum levels of retention. When considering dispersal of harvest operations it may be better to use roving windows at a smaller scale.
	Local landscape just considers harvest boundary (state forest production forest area) not surrounding area. Is this acceptable, meaningful?	Considering only the state forest production forest area is not as ecologically meaningful as considering the entire area. It is possible to do the assessment of the entire area, taking 'advantage' of the retention that occurs in existing formal reserves and ensuring high levels of protection if adjacent to highly modified landscapes. However, considering only the state forest production forest area may be simpler for long term planning.
	Minimum threshold for habitat protection in a local landscape – Is this a good idea?	Applying a minimum level of retention will help maintain biodiversity. Because this approach is not targeted towards particular values (e.g. mature forest) the capacity of this approach to maintain specific values will be variable.
	20% minimum within the local landscape (1500 ha)? Is 20% protected from logging disturbance an appropriate number? If not, what is the appropriate threshold? Is 20% sufficient if nothing retained through other measures and is	There is no 'correct' answer to what is an appropriate level of retention. 20% retention is higher than is applied in many areas, but is at the low end of what is recommended for biodiversity management. Given that both ecological and production outputs need to be maintained, we presume there is little flexibility in this level of retention. It will be important to monitor how effective this level of retention is in meeting its objective. This licence condition will probably best achieve its objective if

Topic	Query	Response
	it a ‘set-aside’ or can it move (floating island concept)? Is it acceptable minimum threshold given the unknowns in the production forestry setting?	the areas are retained over the long term. However, it will be necessary to have a process in place to allow variation in the location of these areas under certain circumstances.
	Would it be best to have fixed local landscapes or could they move around (i.e. a roving window)?	There are advantages and disadvantages to having fixed or roving windows. We suggest that having a fixed window may be the most practical solution for this particular approach.
	Maximum disturbance threshold within a local landscape – Is this a good idea?	It is important to disperse harvesting in space and time. Applying a maximum area that can be disturbed within a specified time frame is one step to helping achieve this.
	Maximum % of area harvested in a certain timeframe as a threshold. Are the amounts appropriate? Is the variation with intensity suitable? Is a 5yr period a good idea or would linking to regeneration state be better? If so, how would this be done?	Having a five year time-frame is a practical approach in that it is easy to implement and audit. However, it will be important to determine if regeneration is assured and the habitat will have adequately recovered within this time frame. Consider using a weighted formula to assess the combined impacts of all types of silviculture. Consider also including provisions to limit harvesting of adjacent areas.
	What is acceptable extent and intensity of harvesting in local landscape scale (1500 ha)?	Using the 1500 ha alone is probably too large a scale at which to assess dispersal of harvesting. We suggest that a small scale of assessment should be used in addition to, or instead of the1500 ha. There is no ‘correct’ solution to the optimal extent and intensity of harvest. These values should be established by considering the ecology of the species in the area and practical constraints.
	Dispersing impact in time and space. If harvesting to basal area < 10 trees/ha basal area then restriction of area to harvest applies- is this defensible?	Forest management in other jurisdictions generally only aims to disperse harvesting when the silvicultural method is intense (e.g. clearfelling). This is defensible as high intensity silviculture has a greater impact than low intensity silviculture. However, even low intensity silviculture can impact some species so dispersing all types of silviculture is desirable if practically possible. The sensitivity of the local species should be taken into account when setting the basal area at which silviculture is classified as ‘high intensity’ and applying restrictions to the area of harvest. If species information is not available then monitoring should be undertaken to determine the effectiveness of this approach.
	Need feedback on need to disperse impacts across time and space.	The ecological literature largely agrees that dispersing harvesting in space and time is beneficial. In some areas it is argued that aggregating harvesting more closely resembles natural disturbance regimes, but we found few instances where this was considered optimal.
	Roving window versus forest harvest area.	Ensuring harvesting is dispersed in space and time would be most effectively assessed using a roving window. Practical techniques for planning and auditing would need to be establishing if a roving window was used.

Topic	Query	Response
Tree retention measures	Feedback on tree retention measures for hollow-bearing species.	When combined with other conditions (e.g. minimum levels of retention) these are likely to contribute to the management of habitat for hollow-using species. It will be important to monitor the effectiveness of this approach.
	Long term retention of trees retained? Approaches used to ensure their survival?	Trees should definitely be retained into the long term to help achieve their objective. Generally trees survive better if they are retained in patches or clumps rather than individually. Also, trees are more likely to survive if they are healthy at the time of retention, are not in exposed areas and are not unduly damaged by fire.
Habitat clumps/patches	Habitat clumps - Are the proposed clump sizes and spatial configurations appropriate? Should aggregating clumps be avoided?	The concept of retaining patches of intact forest within the harvest area is sound. The size of the patches proposed is very small and this will influence their effectiveness in achieving the desired outcome. It may be better to have larger patches retained at larger spacings. Effectiveness monitoring will help determine the most effective size and spacing of habitat clumps.
	Idea is to use it to capture TS feed trees/understorey disturbance minimised/threatened plant requirements etc. Gap filler/connectivity measure. Not needed in low intensity operations but in high intensity operations (is this appropriate?). Not necessarily for hollow-bearing trees although can have some overlap with TS requirements where patches required. Might be better to have options for planners if TS feature from maps.	It is difficult to determine how effective habitat clumps will be in retaining feed trees, understorey plants, threatened species etc. The effectiveness of habitat clumps will depend on the values targeted for retention, the spatial arrangement of these values in a harvest area and how sensitive these values are to edge effects. We recommend that there is flexibility in how these patches are applied (size and spacing) to allow forest planners to adapt them to best achieve the desired outcome. While it is justifiable to only apply habitat clumps in high intensity operations, there will probably also be value in retaining clumps in low intensity operations if possible.
	Are there any other situations where clump provision might be appropriate? High intensity for survival. Info on spatial arrangement size, survival, mitigate mortality.	Retaining special values in clumps is likely to help protect those values over the longer term. For example, habitat trees are expected to survive longer if they are retained in clumps than individually. Habitat clumps may be useful for protecting adult flowering plants as a seed stock for adjacent areas. Habitat clumps can be used to protect nest or den sites.
Landscape connectivity	Widen based on evidence for edge effects? Add patches on to widen? Give edge effect info.	Assuming that the existing corridors and riparian reserves are fixed, it is recommended that there is dispersed retention (patches and individual trees) in the areas between these features to ensure linkages across the landscape and to reduce edge effects.
Burning	Burn boundary comment for retained areas. How to avoid burning if sensitive patch – rainforest?	The following measures may help reduce the chance of direct or indirect effects on retained sensitive patches (e.g. rainforest): - Buffer areas to be protected with intact forest – buffer width should take into account the site conditions (e.g. topography), intensity of harvesting and value retained. - Pull back fuels from the boundary of the retained areas. - Apply technical guidelines for burning using a risk

Topic	Query	Response
		management approach (taking account of factors such as weather conditions, fuel loads, soil moisture, timing of burn etc.) to reduce the chance of the burn escaping into retained areas. - Consider allowing low intensity regeneration burns to enter retained patches if it is compatible (burn intensity and frequency) with the ecology of the area.
Threatened species features – sensitive species	Which conditions may cater for which species (flora and fauna)?	Evaluating the adequacy of the proposed conditions for each threatened species is beyond the scope of this review and it is understood that this will be addressed by future species expert workshops. However, the results of our review indicate that the proposed individual tree and patch retention measures should help address the requirements for some species. If worded appropriately, the individual tree, retention measures and habitat clumps should help address the feed tree requirements of specialised species. The retained areas should help protect disturbance sensitive species (although there will probably be a bias towards riparian species). The maximum harvest measures will help maintain species sensitive to loss of cover.
Monitoring and enforcement	Is the approach appropriate for outcome monitoring – implementation and effectiveness?	The wording of the objectives (outcomes) needs to be adjusted to better facilitate monitoring (see general comments).
	Can the conditions be enforced?	Developing management prescriptions involves consideration of ecological requirements and practicality for implementing and enforcing. The proposed conditions should all be relatively easy to audit, provided the decision-making process is clear and transparent.
	Advice on monitoring and how it can happen. Practical advice on how it can be incorporated into a licence. Concept, link with objective, outcome success monitoring and trend monitoring. Practical implementation.	The licence should state that implementation and effectiveness monitoring need to happen. It can also discuss the roles of the different agencies (in terms of funding, doing the monitoring etc). However, the priority monitoring projects will probably change over time, as some projects are completed or circumstances change. Therefore the process for project identification and prioritisation could occur in a separate document to the licence. However, it is important that monitoring is considered when developing the licence conditions, to ensure that the objective is clear, meaningful and can be monitored.
	Who does what?	Resource savings resulting from cessation of pre-harvest surveys could be directed towards funding a monitoring and adaptive management program. Ideally the effectiveness monitoring should take a collaborative approach involving the EPA, industry and a research provider. The respective roles and responsibilities will depend on the capacity and expertise within these organisations.

1 Introduction

The NSW government, under the *Forestry Act 2012,* developed Integrated Forestry Operations Approvals (IFOAs) for coastal areas utilised for wood production in the late 1990s. The aim of the IFOAs was to integrate and streamline planning and approval processes for forestry operations. The IFOAs contain the terms of a licence under the *Protection of the Environment Operations Act 1997,* the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994* and so set out the terms and conditions under which all forestry operations on State forests and other Crown-timber lands may occur. The IFOAs combined regions are 16.5 million hectares in size; 5.4 million hectares (30.5% of total) is public land (3.8 million or 22% of total in National Parks and 1.6 million or 9% of total in State Forest) and the rest is private land.

A review of the four coastal IFOAs in 2010 identified major difficulties with the implementation and enforcement of the IFOA conditions (NSW Government 2010). Some changes have been made but it has been noted that issues remain that make the IFOAs difficult to understand, implement and monitor (NSWEPA 2013). A process to develop a single Integrated Forest Operations Approval (IFOA) for the coastal forest estate of NSW (Eden, Southern (including Tumut subregion) Lower North East and Upper North East) was therefore initiated (NSWEPA 2013) (Figure 1). As part of this process a first stage agreement to streamline the conditions for the management of threatened species has been prepared jointly by the NSW Environment Protection Authority, the Department of Primary Industries (Fisheries) and the Forestry Corporation. The overall goal of the IFOA remake is to reduce costs associated with implementation and compliance and improve clarity and enforceability of the IFOAs whilst ensuring no net change to wood supply and no erosion of environmental values (NSWEPA 2013). The specific goal of the Threatened Species Licence issued under the *Threatened Species Conservation Act 1995* is to mitigate impact on land-based threatened species.

A framework for the management of habitat for a broad suite of species, including threatened species, has been agreed with stakeholders and a paper has been prepared for public consultation (EPA et al. 2013). The NSW project team approached the Research and Advisory Section of the Tasmanian Forest Practices Authority (FPA) for independent comment and advice on the draft Threatened Species Licence (TSL) conditions still under development (EPA et al. 2013, NSWEPA 2013).

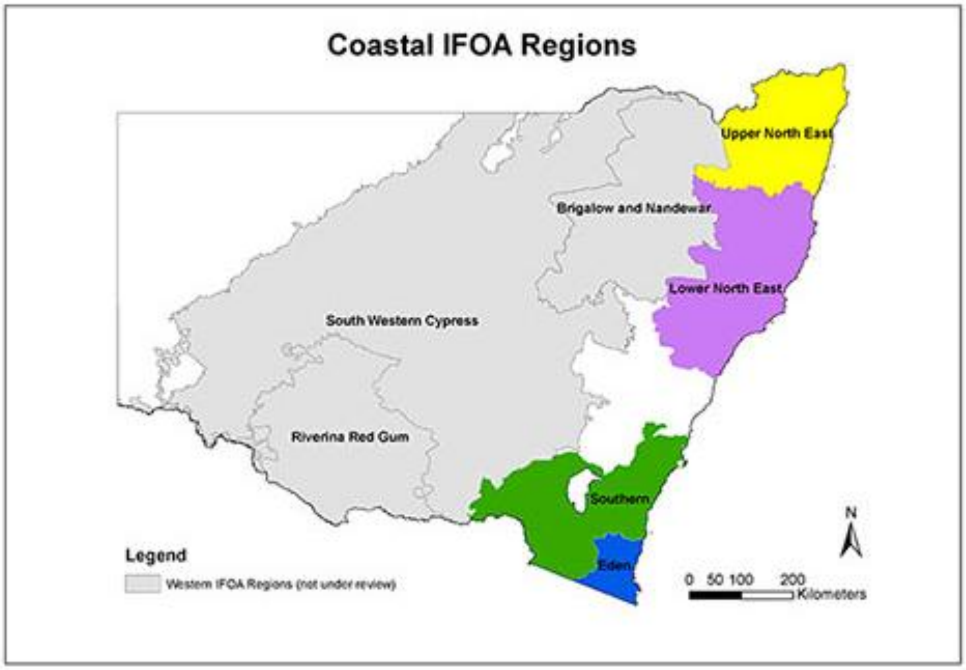

Figure 1 Coastal IFOA regions.

1.1 Aim and scope of this report

The preliminary report (Munks et al. 2014) provided to the NSW team to meet Milestone 1 (Appendix A) provided general commentary on the outcomes, licence concepts and recommended actions in the draft IFOA agreement paper for the Threatened Species licence (TSL) (EPA et al. 2013).

The aim of this final report is to address the specific queries raised in the *Remake of the Coastal Integrated Forestry Operations Approvals* report (NSWEPA 2013), relating to the conditions of the Threatened Species Licence (EPA et al. 2013), and additional queries raised during the fieldtrip and Sydney meeting in January 2014 . This report meets Milestone 2 of the contract schedule (Appendix A).

Table 1 Specific queries relating to the TSL conditions, raised by the NSW project team (NSWEPA 2013)**.**

Topic	Query
General approach – The overall licence concept	• What are the gaps?
	• What aspects of the approach may be hard/ problematic?
	• In what way could the approach be improved / adapted to meet the overall goal?
Local landscape conditions	• Is 1500 ha an appropriate scale for considering local landscape scale objectives?

	• Is this size meaningful ecologically? Is this appropriate for management? Definition of landscape – what has been done elsewhere? • Are discreet local landscapes the way to go (group of compartments)? Or should it be a roving window (each harvestable areas and surrounding area)? • Local landscape just considers harvest boundary (state forest production forest area) not surrounding area. Is this acceptable, meaningful?
	• Minimum threshold for habitat protection in a local landscape – Is this a good idea? • 20% minimum within the local landscape (1500 ha)? Is 20% protected from logging disturbance an appropriate number? If not, what is the appropriate threshold? Is 20% sufficient if nothing retained through other measures and is it a 'set-aside' or can it move (floating island concept)? Is it acceptable minimum threshold given the unknowns in the production forestry setting?
	• Would it be best to have fixed local landscapes or could they move around (i.e. a roving window)?
	• Maximum disturbance threshold within a local landscape – Is this a good idea? • Maximum % of area harvested in a certain timeframe as a threshold. Are the amounts appropriate? Is the variation with intensity suitable? Is a 5yr period a good idea or would linking to regeneration state be better? If so, how would this be done? • What is acceptable extent and intensity of harvesting in local landscape scale (1500 ha). • Dispersing impact in time and space. If harvesting to basal area < 10 trees/ha basal area then restriction of area to harvest applies- is this defensible? • Need feedback on need to disperse impacts across time and space. • Roving window versus forest harvest area.
Tree retention measures	• Feedback on tree retention measures for hollow-bearing species. • Long term retention of trees retained? Approaches used to ensure their survival?
Habitat clumps/patches	• Habitat clumps - Are the proposed clump sizes and spatial configurations appropriate? Should aggregating clumps be avoided? • Idea is to use it to capture TS feed trees/understorey disturbance minimised/threatened plant requirements. etc. Gap filler/connectivity measure. Not needed in low intensity operations but in high intensity operations (is this appropriate?). Not necessarily for hollow-bearing trees although can have some overlap with TS requirements where patches required. Might be better to have options for planners if TS feature from maps. • Are there any other situations where clump provision might be appropriate? High intensity for survival. Info on spatial arrangement size,

	survival, mitigate mortality.
Landscape connectivity	• Riparian zone linkages/catchment/hydrological issues. • Individual prescriptions/assessments. • Ridge and headwater buffers stay. 1 x80m or 2x40m wide. • Widen based on evidence for edge effects? Add patches on to widen? Give edge effect info.
Burning	• Hazard reduction burns covered elsewhere. Only silvicultural burns covered in this licence – pre-harvest and post-harvest burning. • Recommendation for clumps/patches – as in Tas, ok in general for light/cool burn. • Burn boundary comment for retained areas. How to avoid burning if sensitive patch – rainforest.
Threatened species features – sensitive species	• Which conditions may cater for which species (flora and fauna).
Monitoring and enforcement	• Is the approach appropriate for outcome monitoring – implementation and effectiveness? • Can the conditions be enforced? • Advice on monitoring and how it can happen. Practical advice on how it can be incorporated into a licence. Concept, link with objective, outcome success monitoring and trend monitoring. Practical implementation. • Who does what?

2 Methods

The NSW project team provided the FPA with documents that covered a draft (proposed) approach for the conservation of forest dependent threatened species in State Forests in NSW through an Integrated Forestry Operations Approval process (EPA et al. 2013, NSWEPA 2013).

Initial comments were provided to the NSW project team in December 2013 (Munks et al. 2014) (Appendix B). Feedback was received from the NSW project team and issues were discussed during a fieldtrip to relevant sites in January 2014 (Appendix A).

Our comments and response to the queries relating to each topic (Table 1) are based on the information provided, outcomes from the field discussions and follow-up meetings with members of the NSW project team (Michael Pennay, NSW EPA, Justin Williams, FNSW), information gathered during this review , experience gained through the implementation and monitoring of biodiversity provisions for the Tasmanian Forest Practices System over the past two decades and reviews of overseas approaches by the FPA project team (Koch 2007, Koch et al. 2011, Munks and Koch 2011, Koch et al. 2011b).

As detailed in the contract schedule (Appendix A) the advice and recommendations are made with consideration of (i) the key general/ broader impacts to threatened species from forestry operations (acknowledging that some impacts are species or site specific and these will be dealt with individually where appropriate through a separate consideration) and (ii) the operational and environmental effectiveness of approaches taken in Tasmania (and other Australian native forests where appropriate) to conserve threatened species and biodiversity under codes of practice.

3 General comments on the overall licence approach

General comments and recommendations on the approach proposed in the draft agreement paper for the Threatened Species licence (TSL) (EPA et al. 2013) were made in the preliminary report (Munks et al. 2014) (Appendix B). Many of these recommendations are still relevant and should be considered as part of this final report.

3.1 What are the gaps?

3.1.1 General conditions

In order to identify possible gaps we considered the contribution made by the revised licence conditions (EPA et al. 2013) to the overarching goals and sub-objectives identified in the literature as important for the conservation of forest biodiversity outside of formal reserves (Lindenmayer and Franklin 2002, Lindenmayer et al. 2006) (Table 2). In general there are TSL licence conditions for each goal and they cover the three broad management categories consistent with the approach taken in other jurisdictions (Koch et al. 2011) –

1. landscape-level measures for retention, maintenance or restoration of habitats,
2. protection of aquatic systems and networks, specialised habitats, biological hotspots,
3. retention of structural and habitat features at the operation level.

Some gaps, however, were identified (Table 2). These included

- conditions specifically relating to post-harvest regeneration of habitat,
- conditions that related to the design and management of the road network and stream crossings to take into account impact on species, in-stream and riparian and hydrological processes,
- conditions that relate to the management of pests, disease and genetic pollution,
- conditions to reduce edge effects (e.g. low intensity silviculture in a zone buffering reserves or sensitive species habitat),
- conditions to cater for forest remnants of high conservation value,
- conditions for the maintenance of soil fertility and structure,
- conditions to cover harvest dispersal in time and space (although the maximum harvest threshold will contribute).

Some of these, however, may already be covered by the general conditions in the environmental protection licence (EPL) and the fisheries licence (FL).

Table 2. Evaluation of the contribution made by the revised licence conditions (EPA et al. 2013) to the overarching goals and sub-objectives identified as important for the conservation of forest biodiversity (Lindenmayer and Franklin 2002, Lindenmayer et al. 2008, Forest Practices Authority 2013).

Goals	Sub-objective	Main contributing TSL licence conditions	Comment*
1. Maintain an extensive and permanent native forest estate and avoid or minimise any permanent forest loss.	**1.1** Maintain native forest.	N/A	Covered by other legislative and policy mechanisms.
	1.2 Maintain and/or enhance the area and/or condition of threatened or priority native vegetation communities on state forest.	Threatened ecological communities • Identification through approved TEC maps and field guides • Protection of specific values of a TEC Conditions for protection of threatened species habitat at a broad landscape scale • Protection of oldgrowth, rainforest, rare non-commercial forest types • Wetland protection • Heath and scrub protection • Rocky outcrop protection	An additional condition may be required to cater for high conservation value remnants within the production landscape.
	1.3 Ensure forestry does not result in any non-threatened forest community becoming threatened.	Local landscape (1500 ha) conditions • Minimum retention threshold (20%) • Maximum disturbance threshold. Habitat clump conditions • Patches of trees retained in harvest area Landscape connectivity conditions • Riparian habitat protection • Ridge and headwater protection Conditions for key threatening processes	
2. Maintain or improve landscape heterogeneity.	**2.1** Maintain the full range of seral stage pattern in native	Local landscape (1500ha) conditions • Minimum retention threshold (20%)	Further consideration of conditions to cover harvest dispersal in time and space required.

Goals	Sub-objective	Main contributing TSL licence conditions	Comment*
	forests.	• Maximum disturbance threshold Habitat clump conditions • Patches of trees retained for the long term in harvest areas Landscape connectivity conditions • Riparian habitat protection • Ridge and headwater protection Conditions for protection of threatened species habitat at a broad landscape scale • Protection of oldgrowth • Rocky outcrop protection • Owl landscape protection	
	2.2 Ensure adequate regeneration in native forest harvest areas is achieved during each harvest cycle, including regeneration of the understorey.	Burning conditions • Post harvest burning excluded from fire sensitive areas	The need for adequate regeneration following harvest is not specifically covered in the TSL licence. However, the TSL conditions for burning and 'recruit' tree conditions will contribute.
3. Maintain connectivity of habitat for flora and fauna species.	**3.1** Maintain and/or enhance linkages along water courses and between water courses, capturing a range of habitat types and topographies.	Landscape connectivity conditions • Riparian habitat protection • Ridge and headwater protection	
4. Maintain and/or improve the condition of freshwater ecosystems.	**4.1** Maintain water quality and flow within the range of natural variation over time.	Local landscape (1500 ha) conditions • Minimum retention threshold (20%) • Maximum disturbance threshold Landscape connectivity conditions • Riparian habitat protection • Ridge and headwater protection	Need for additional conditions for roading and bridge/culvert construction, management of water catchments.

Goals	Sub-objective	Main contributing TSL licence conditions	Comment*
	4.2 Maintain and/or restore riparian vegetation and in-stream habitat.	Landscape connectivity conditions • Riparian habitat protection • Ridge and headwater protection	Need for additional conditions for roading and bridge/culvert construction, hydrological considerations and restoration of riparian areas.
5. Maintain and/or improve the condition native habitats for flora and fauna, particularly priority species.	**5.1** Manage the risk of introducing pests and disease into a 'healthy' habitat.	Not covered	Need conditions to avoid introduction of pests and diseases into harvest areas. Recommend the development of a disease management plan with particular emphasis on minimising the deleterious effects of declared environmental weeds in native forests.
	5.3 Minimise harmful edge effects on reserves and sensitive vegetation communities and sensitive priority species habitat.	Conditions for protection of threatened species habitat at a broad landscape scale • Protection of oldgrowth, rainforest, rare non-commercial forest types • Wetland protection • Heath and scrub protection • Rocky outcrop protection Burning conditions • Post harvest burning excluded from fire sensitive areas	Additional conditions may be needed to reduce edge effects (e.g. low intensity silviculture in a zone buffering reserves or sensitive species habitat).
	5.4 Maintain soil fertility and structure.	Not covered	While there are no specific conditions in the TSL for this sub-objective, all the conditions will contribute indirectly to the maintenance of soil fertility and structure. Additional conditions relating to silvicultural practice, roading, harvesting and regeneration techniques are required.
6. Maintain and/or improve the conservation status of forest species and	**6.1** Maintain populations of threatened species throughout their ranges, through the	Local landscape conditions • Minimum retention threshold (20%)	Development of species-specific management actions for some threatened species.

Goals	Sub-objective	Main contributing TSL licence conditions	Comment*
their natural levels of genetic diversity.	management of potential habitat (breeding and foraging), facilitating recolonisation and other management actions.	• Maximum disturbance threshold Conditions for protection of threatened species habitat at a broad landscape scale • Protection of oldgrowth, rainforest, rare non-commercial forest types • Drainage feature protection • Ridge and headwater corridors • Wetland protection • Heath and scrub protection • Rocky outcrop protection • Nest, roost and den site protection • Owl landscape protection Habitat clump conditions • Patches of trees retained in harvest area Tree retention conditions • Minimum number of habitat and 'recruit' trees retained into the long term • Giant tree retention Conditions for species not adequately protected by the general licence conditions • Additional species or site-specific conditions to mitigate potential harm (e.g. koala conditions) • Develop and implement existing and new species management plans and habitat maps	

*Note that the gaps in the conditions identified in the comments section of this Table may already be included in other licence conditions (e.g. Environmental planning licence (EPL) or the Fisheries licence (FL))

3.2 What aspects of the approach may be hard/ problematic?

3.2.1 Conflicting 'outcomes'

The legislative and policy framework which sets the agenda for the conservation of biodiversity in NSW, as elsewhere, is complex. The IFOA framework includes four pieces of legislation and, while the aspirations of these instruments may be clear, there is a risk of conflicting objectives and uncertainty when it comes to achieving their practical application. This may have ramifications for evaluating the success of the new 'outcome-based' approach in ensuring no net change to wood supply and no erosion of environmental values (NSWEPA 2013) and opportunities for continual improvement. It is recommended that overarching guiding principles are developed that describe the contribution forests covered by IFOAs are expected to make to threatened species conservation (and biodiversity in general) to complement the formal reserve system in NSW. These principles should take into account the objectives of the Acts and the fact that conservation outcomes for forests that are set aside for economic resource use (such as wood production) will be different to those for forests set aside primarily for nature conservation (formal reserves).

3.2.2 Flexibility and enforcement

It is proposed that the new IFOA includes a hierarchy of outcomes and conditions supported by protocols and supplementary guidance material. The intent is to provide FCNSW with flexibility in how the outcomes might be achieved whilst still providing certainty in terms of expected compliance outcomes (NSWEPA 2013). This approach is generally considered more practical and efficient when compared to the more prescriptive approach. However, as mentioned in the preliminary report (Munks et al. 2014), problems may arise in both implementation and compliance monitoring if the intended 'outcome' or objective is not clear and measurable to those tasked with the job of implementing and monitoring the actions.

Comprehensive guidelines and a program of training and awareness raising for forest planners, contractors and those involved in monitoring compliance would go a long way toward avoiding confusion and lack of consistency in interpretation of the outcomes and conditions. An EPA co-ordinated training program and advisory service for forest managers would also help to ensure the desired outcome is achieved. The effectiveness of the outcome-based approach would be further enhanced by referring to agreed guidelines/planning tools in the licence conditions.

In addition to training and guidance material, protocols could be developed to document the decisions made by planners when implementing actions to meet the conditions and overall outcome. These protocols could then be taken into account when monitoring compliance with the licence condition.

3.3 In what way could the approach be improved given the current context?

Some ways in which the approach could be improved to meet the goals of the IFOA remake and the TSL licence, in particular, have already been mentioned in the preliminary report (Munks et al. 2014) and in the above sections – gaps in conditions, avoiding/dealing with conflicting outcomes, training, guidance material and procedures to enable flexibility whilst also ensuring enforceability. Another important area for further consideration is the need for a monitoring and reporting program, in particular further work on the structure of the proposed outcomes and a continual improvement process. Where conservation and production objectives conflict it is important that these are resolved and that all parties agree on the questions to be answered before embarking on a monitoring program undertaken as part of an adaptive management framework. A process to enable continual improvement needs to be agreed by all stakeholders and this should include consideration of the science and socio-economic consequences of any changes proposed as a result of monitoring. All stakeholders prefer certainty but for an outcome-based approach to work there needs to be general acceptance that goal-posts may change as a result of monitoring. A clear and transparent 'continual improvement' process involving all stakeholders could help with this acceptance. Section 10 covers this in more detail.

4 Local landscape conditions

4.1 Proposed condition for the TSL

The proposed 'outcome' or objective for the local landscape conditions in the revised TSL (EPA et al. 2013) is "to ensure thresholds for habitat protection and a range of successional stages are met at the local landscape scale to ensure adequate food and habitat resources are available, and enhance the opportunities for recolonisation of areas disturbed by forestry activities by threatened flora and fauna".

The two conditions proposed to achieve this objective (EPA et al. 2013) are -

1. A minimum threshold (e.g. 20%) of the area within the native forest area of the local landscape (1,500 ha) must be excluded from harvesting (e.g. in protection zones). Where the minimum threshold is not met through existing exclusion zones additional protection zones must be implemented to reach the threshold.

2. A maximum threshold for the amount of area in the local landscape (1,500 ha) recently disturbed (within past 5 years) by forestry activities. Maximum threshold percentages for harvesting would apply at different levels for a range of intensities of operations.

Information to address the queries raised by the NSW team in relation to these conditions (Table 1) and their overall effectiveness in meeting the desired outcome is provided in this section.

4.2 Brief review of relevant information

Some sensitive species can be affected by habitat loss and fragmentation in forestry landscapes. To be useable, habitat needs to be accessible, and of adequate health and size. Many species can use, or at least move through harvested areas (Vanderwel et al. 2009). However other species can be strongly edge-effected or extremely sensitive, even to partial harvest silviculture (Vanderwel et al. 2009, Gustafsson et al. 2010). Effectively managing the threats of habitat loss and fragmentation will generally require a local landscape approach to managing the spatial and temporal impact of harvesting, to ‘spread the risk’ of forestry activities (Lindenmayer and Franklin 2002).

4.2.1 Retention in forestry areas

Retention of unlogged forest within the forestry landscape is an approach taken to biodiversity management in many parts of the world. In some areas the amount retained is variable, and targeted towards specific features. However there is an increasing trend towards retaining pre-established thresholds of forest that do not target any particular features, especially with the increasing application of ‘retention forestry’ (Gustafsson et al. 2012). The objectives of retention forestry include “(a) maintaining and enhancing the supply of ecosystem services and the provisioning of biodiversity..., (b) increasing public acceptance of forest harvesting and the options for future forest use.... (c) enriching the structure and composition of the postharvest forest..., (d) achieving temporal and spatial continuity of key habitat elements and processes, including those needed by both early- and late-successional specialist species...., (e) maintaining connectivity in the managed forest landscape...., (f) minimizing the off-site impacts of harvesting, such as on aquatic systems...., and (g) improving the aesthetics of harvested forests” (Gustafsson et al. 2012).

4.2.1.1 Level of retention

In practice, the level of retention of unlogged forest or trees achieved in forestry areas is highly variable; from between 1–3% of the harvested volume to more than 40% (Gustafsson et al. 2012). Retention levels tend to be lower in areas with a long history of forestry activity and modified natural forests (Gustafsson et al. 2012). In some regions different levels of retention are required in different landscape zones depending on management and conservation priorities (Koch et al. 2011). Retention requirements can be defined as a percentage of the total (or a specified) area, a percentage of the basal area, or by having a minimum percentage of the harvested area in close proximity to an unharvested boundary (i.e. a minimum percentage under ‘forest influence’).

There is limited information available on how particular thresholds are developed, but it appears that ecological data is often not the only information used, or is not available, when establishing thresholds. Retention thresholds are often a realistic and practical trade-off between conservation and economic activity. For example, in the Pacific Northwest of the USA the level of retention was developed from expert opinion (Aubry et al. 1999). In Tasmania, the level of retention proposed by the State Forest government business enterprise (Forestry Tasmania) was determined by nature conservation objectives as influenced by statutory obligations to meet wood volume targets within designated wood production zones.

The benefits of retention for biota that are sensitive to harvesting generally increases with the level of retention. The *minimum* level of retention needed to have positive ecological outcomes varies. In a review of retention forestry it was suggested that at least 5–10% retention is needed, but higher levels are generally advocated (Gustafsson et al. 2012). Examination of variable retention harvests in the Pacific Northwest recommended that at least 15% retention is needed to effectively retain sensitive species (Aubry et al. 2009). While 30% habitat retention is promoted as a lower threshold in other studies (Andren 1994). Even high levels of retention, however, may not maintain all species in a forestry landscape (e.g. highly sensitive or area-demanding species). Research done in the tall, montane forest east of Bombala concluded that greater glider (*Petauroides volans*) populations were likely to be maintained at or near pre-logging levels when at least 40% of the original tree basal area is retained throughout logged areas and when the usual practice of retaining unlogged forest in riparian strips is applied (Kavanagh 2000).

A study in the Pacific Northwest assessed the biological responses of plants, small mammals and birds to varying levels (100%, 75%, 40% and 15%) and patterns of retention (for the two lower levels of retention, trees dispersed uniformly or in 1 ha patches) (Aubry et al. 1999, Aubry et al. 2009). Higher levels of retention were found to be needed for many species sensitive to harvesting (Aubry et al. 1999). The response varied between species, with some taxa (e.g. ectomycorrhizal fungi and late-seral herbs) responding in proportion to the level of overstorey removal, other taxa having equivalent impacts for low and moderate intensity harvesting (e.g. forest-floor bryophytes, predatory litter-dwelling arthropods, western red-backed vole), and other species showing no response to harvesting (Aubry et al. 2009). Greater biodiversity benefits are expected to occur if the level of retention is higher and size of retained patches is larger (Aubry et al. 2009, Wardlaw et al. 2012).

4.2.1.2 Areas targeted for retention

In many jurisdictions prescriptions for retention of unlogged forest at the local landscape-scale do not specify capturing a particular habitat or structural element. The effectiveness of such untargeted retention depends on the objective (reason for the retention), the ecology of the species that need to be managed, the landscape context and the areas that are retained in practice. Retention requirements are often met through areas set aside for the protection of soil and water values (e.g. riparian areas), but species composition can change between riparian and non-riparian areas (Baker et al. 2006). If the objective in a particular area is to maintain populations of species with a particular structural requirement (e.g. hollow-using species) then such habitat may need to be targeted when meeting the retention threshold or additional measures applied (Kavanagh 2000, Munks et al. 2009).

Several studies have demonstrated the importance of managing mature forest across the production forest landscape in order to cater for multiple species. A large-scale study in forestry areas in wet forest in southern Tasmania looked at the number of species of plants, birds and beetles in regrowth and mature forest with different contexts of mature forest in the surrounding landscape (Wardlaw et al. 2012). The study concluded that most of the species examined were maintained in mature forest patches (min size 2 ha) regardless of the context, while species richness and abundance in regrowth areas was influenced by the amount of mature forest in the surrounding landscape (Wardlaw et al. 2012). Our interpretation of the results suggests that maintaining approximately 20–30% mature forest in the landscape will help to maintain species in harvested areas. A study on bats in dry forest in Tasmania found that maternal colonies generally occurred in areas of the landscape with the highest availability of hollow-bearing trees. Bat activity was higher in small patches (0.1 ha) where mature forest in the surrounding landscape was <22% within a 1km radius (Cawthen et al. 2013). These studies illustrate the importance of considering the availability of habitat in the broader landscape when managing mature forest features and assessing management effectiveness.

Retaining untargeted areas has been shown to have biodiversity benefits, but untargeted retention may not cater for the requirements of all species. It is therefore important that the use of threshold retention levels is considered in conjunction with the full suite of prescriptions for managing biodiversity. In some areas, it may be necessary to target the retention to capture particular features, or adopt additional measures to ensure suitable habitat is retained.

4.2.1.3 Configuration

Actions taken to meet retention targets may vary from evenly distributed individual trees, to intact patches or strips of forest varying in size and shape. In some regions, guidelines about the proximity of harvested areas to retained structures or patches are employed to ensure that large 'gaps' are avoided (Baker and Read 2011).

Patch or strip retention is generally regarded as more beneficial than dispersed retention (single trees or small clumps <1ha), although a study in the Pacific Northwest, USA, found the pattern of retention had little effect on most taxa examined (Aubry et al. 2009). However, retention in patches can reduce damage and mortality to retained trees and edge-affects (Aubry et al. 2009). Adopting patch, strip and dispersed retention in a particular area will help 'spread the risks' and ensure the requirements of most species are met.

4.2.1.4 Permanency

Retained areas may be retained indefinitely, for a nominated time (e.g. 100 years) or until the next harvest. When determining the permanency of retained areas it is important to consider the ecological objective of these areas. In many situations the retention will need to be long-term to meet the ecological objective. However, in some circumstances it can be beneficial to have flexibility in the system, allowing the location of the retained areas to change as the ecological values change (e.g. as a result of wildfire).

For values that do not require long time frames to develop, it may be appropriate to use Optimized Floating Refugia (OFR) (Ramage et al. 2013). Floating refugia are areas that are not disturbed in the current period, but can be disturbed in later periods. The concept behind OFR is that species are more likely to persist if all habitat within their range is not disturbed at the same time. The OFR approach allows flexibility in management, but will only be valuable if applied at appropriate timeframes. For example mature forest features, such as tree hollows, are unlikely to develop in the standard intervals between harvest operations (Lindenmayer et al. 1993, Koch et al. 2008). Therefore floating refugia for mature forest management could be applied, but the best areas for retention are unlikely to change location after successive harvest unless other disturbances occur. The OFR approach is unlikely to benefit logging-sensitive species confined to a single stand or species unlikely to disperse between stands (Ramage et al. 2013).

4.2.2 Dispersing harvest operations

Decisions regarding harvest operations in time and space, in particular dispersion versus concentration of activities are complex, they are generally made in the context of biodiversity goals, economic and practical constraints and social acceptability (Lindenmayer and Franklin 2002). The main message from the literature is to spread the risks by creating a range of conditions and spatial patterns (Lindenmayer and Franklin 2002). Areas that have been subject to intensive disturbance may be better managed through dispersing forestry activities thereby improving overall habitat levels and connectivity. In other areas concentration of activities in time and space may be best.

Dispersed harvesting seems preferable for the majority of sensitive species (Ramage et al. 2013). However, dispersed harvesting can have some negative impacts, such as a higher distribution of roads and greater fragmentation of mature forest (Baskent and Keles 2005). It may be beneficial to aggregate harvesting in some areas, particularly when aggregated harvesting more closely emulates natural disturbance patterns (Carlson and Kurz 2007). Aggregated harvesting may also be preferable for highly mobile species that require expansive areas with similar structures, but Reviews of the spatial and temporal management of landscapes (Baskent and Keles 2005, van Teeffelen et al. 2012) have identified some key techniques for mitigating the negative impacts of repeated disturbances, including enlarging the network area, decreasing the intensity of habitat turnover, avoiding clustered habitat loss, and applying more frequent smaller impacts than infrequent intense impacts (Box 1) (van Teeffelen et al. 2012). Some examples of approaches taken to harvest dispersal are provided in Table 3.

There is considerable research looking at how to plan harvests to account for spatial considerations (Baskent and Keles 2005). Issues often considered are the size, shape, composition, juxtaposition and distribution of management units (harvest blocks, wildlife habitat and age class). Some of the techniques for managing the spatial and temporal impact of harvesting include having a maximum harvest unit, applying adjacency rules, or applying spatiotemporal selection of harvest operations.

The ‘maximum harvest unit’ involves regulating the maximum size of a harvest operation, generally a clearfall operation. Generally smaller harvest units are seen as preferable to larger harvest units (van Teeffelen et al. 2012). The maximum harvest unit approach is often used in conjunction with the 'adjacency' constraint, where harvesting is prevented in adjacent areas for a certain time period. Adjacency can be defined as areas sharing a border, or areas within a specified distance from each other (Baskent and Keles 2005). The adjacency constraint can either be set regardless of the size of the harvest unit (e.g. for clearfelling in Tasmania), or the threshold is applied at the maximum opening size - meaning a number of operations can occur in the area as long as they do not collectively exceed the maximum harvest unit size (Baskent and Keles 2005).

Application of the adjacency principle can be more or less suitable, depending on the circumstances. For example the adjacency principle could be used in areas which are in an early stage of fragmentation, but in fragmented areas it may be preferable to leave some of the existing old forest clusters undisturbed and concentrate harvesting elsewhere (Kurttila 2001). Zoning the landscape for different management priorities can help determine when to apply different management approaches (Koch et al. 2011).

Box 1. Approaches to improving species persistence by managing the spatial and temporal availability of habitat (van Teeffelen et al. 2012).

Spatial properties

- Enlarge existing retained area.
- Enlarging large patches is more effective than enlarging small patches.
- To buffer against habitat turnover, 20–60% of a landscape should consist of habitat.
- To achieve comparable species viability levels between static and dynamic networks, dynamic networks must be 1.2–3.5 times larger than static networks.
- Increase network connectivity.
- Networks with relatively few large patches may be preferred over networks with many small patches (although not by all species).
- Networks with patches of different sizes seem to be more robust than networks with equal-sized patches.

Temporal properties

- Reduce the proportion of the network that is subject to disturbance.
- It is better to disperse rather than aggregate patterns of patch destruction in space unless species are severely dispersal limited.
- Conduct habitat restoration near source populations and as quickly as possible.
- Reduce the disturbance rate unless species require a disturbance for habitat or life cycle events.
- Frequent yet mild disturbances are preferred over rare yet severe disturbances.
- It is preferred to distribute patch disturbance homogeneously over time.
- Reduce disturbance intensity whenever possible.
- On average, patch life time should exceed species generation time.

Spatio-temporal selection of harvest operations has historically focused on the percentage, volume, or acreage of an area or region managed under a particular regime. Models and algorithms are now available to help select the optimal order of harvesting to meet pre-defined criteria, such as the maximum harvest unit and adjacency rules (Baskent and Keles 2005).

The impact of harvesting may also be managed by limiting the intensity of the harvest that can occur in a particular time frame. For example, in Brazil mechanized harvesting operations, require a 25 to 35 year cutting cycle with a maximum logging intensity of 30 m^3/ha, and for non-mechanized/low intensity harvests require a 10 year cutting cycle with a maximum logging intensity of 10 m^3/ha (Zarin et al. 2007). In British Columbia, up to 80% of the area is available for harvest in areas designated as 'timber zone'. In the 'habitat zone' where the goal is conservation, there is a minimum retention of 15% and no more than 70% of the forest area is available for harvest. In the 'oldgrowth zone' the minimum level of retention is 20% and approximately 67% of the area is to be reserved from harvesting, which must occur by an uneven-aged silviculture (Koch et al. 2011). A similar zoning approach was developed for production forests in SE Queensland (Lamb et al. 1998).

The greater the level of retention in the harvested area, the less impact that harvesting will have on biodiversity. A review of partial harvesting systems in Ontario, Canada, found that retaining 70% of the basal area caused few species to exhibit reduced habitat use, although some sensitive passerine birds may be negatively affected (Vanderwel et al. 2009). At 50% retention about 40% of the species considered displayed a reduction in abundance, particularly cavity- and snag-dependent species and passerine birds that forage or nest in the canopy and understory. Higher intensity operations that retained 30% of the basal area provided unsuitable habitat for about one quarter of all late-successional species (Vanderwel et al. 2009). Metrics can be a useful tool for assessing the outcomes of the planning (e.g. total edge length, total core area, mean distance to the nearest neighbour, proportion of a specified boundary type in relation to the total boundary length, spatial autocorrelation, and location-weighted mean of a specified stand characteristic) (Baskent and Keles 2005).

Table 3. Overview of the ways that harvest units are dispersed in space and time in a selection of areas (Koch et al. 2011).

Region	Approach
Victoria	Minimum coupe dispersal applied. The regulator designates areas for harvest, which is generally harvested intensively.
Queensland	The regulator has the capacity to determine the spatial distribution of harvesting areas through its planning processes. Coupe dispersion seems to occur to some, but only a limited extent due to logistical considerations.
Western Australia	In some areas at least 30% of the catchment needs to remain unharvested for hydrological and salinity-related reasons. Some stand structure management also occurs because they try to stick to the historical burn regime.
Sweden	No more than half of forest management units larger than 50 ha may be younger than 20 years, and forest areas larger than 1000 ha are subject to further restrictions.
Ireland	In grant-aided afforestation areas, approximately 15% of the area (when greater than 10 ha) should be retained as open space for biodiversity enhancement.

4.3 Comment on proposed conditions and response to queries

4.3.1 Minimum threshold for habitat protection in a local landscape

4.3.1.1 Is this a good idea? Is the threshold level appropriate? Can it cater for habitat? Are retained areas 'set-aside' or can they move?

Information gathered during this review (Section 4.2) supports the adoption of a minimum threshold for habitat retention. Retention of unlogged forest throughout the local landscape will provide habitat and facilitate recolonisation of harvested areas by fauna species. Which species are catered for depends on a number of factors, including the level of retention and type of habitat retained. The degree to which this condition will achieve the objective of maintaining seral stages depends on the areas selected for retention.

The retention level currently proposed in the revised TSL condition is 20% of the local landscape. Information in the literature indicates that this will make a contribution to maintaining biodiversity (including threatened species) within the broader landscape. When assessing the adequacy of the proposed 20% threshold from an ecological perspective it will be necessary to consider the landscape context for a particular area.

In forestry areas maintenance of seral stage pattern generally requires greater focus on the management of the older seral stages than the younger ones. Conditions for the retention of areas identified as 'oldgrowth', individual hollow-bearing trees and for other reasons will, however, cater for older seral stages and mature structures to some degree. The adequacy of the combined measures for managing mature forest and different seral stages should be monitored. Other habitats though may not be adequately captured by the proposed untargeted approach (e.g. different vegetation communities, foraging habitats, refuge habitats). Guidelines for planners that emphasise the importance of targeting older stands, getting a representation of different vegetation types, capturing threatened species and non-riparian habitat, having larger rather than smaller retained patches, and trying to ensure there are not large 'gaps' in retention will help maximise the ecological benefit of the minimum threshold in the local landscape.

To maximise the biodiversity benefits of the retained areas, the areas selected for retention will probably need to be retained for the long-term. However, some areas may need to be 'moved' for logistical or ecological reasons. A clear and transparent approval process would help facilitate this. Alternatively, areas could be retained for a nominated time frame (e.g. 100 years) or until a time agreed between the regulator and industry.

4.3.1.2 Are the definition and scale 1500 ha appropriate for a 'local landscape'?

The importance of multi-scaled landscape management for biodiversity is recognised in the literature (Lindenmayer and Franklin 2002). The concept of 'landscape', however, is broad, vague, and means different things to different people. Different landscape units may be appropriate for managing different components of biodiversity at different scales. For example, at the broad scale river catchment boundaries may be appropriate when managing stream biota whereas forest type units or bioregions may be more useful when managing terrestrial biota. Local landscape-scale (or 'mid-scale') planning can help to ensure 'landscapes' have the features required for biodiversity management, including connectivity and heterogeneity. There is no clear or 'correct' size at which management becomes 'mid-scale', but we propose that it is a number of times larger than the home ranges of most species. Sub-catchment, property or forest block may be useful at the mid-scale.

When defining the local landscape it is important to consider what is both ecologically meaningful and practical. The suggested definition of the local landscape for the TSL is a State Forest compartment with a maximum size of 1500 ha. This is larger than the home range, and potentially even the entire range, of some species and is larger than the scale used in many areas, but there is increasing recognition of the importance of managing at a larger scale. Therefore this scale is considered appropriate for ensuring 'landscape' or 'mid-scale' management. Differentiating by land tenure is not ecologically meaningful but is a widely-used approach. Taking all land tenures into account could mean higher levels of retention are required in some areas adjacent to cleared private land, but lower levels of retention would be required if adjacent to formal reserves.

If the local landscape conditions are applied at the 1500 ha scale then it is important that monitoring to evaluate their effectiveness is designed appropriately. Metrics for assessing connectivity and heterogeneity, potentially using GIS software, could be developed for use during planning and monitoring (including auditing for compliance) to determine if the desired outcomes are being achieved at this scale. An alternative or additional option for local landscape scale management could be to zone the landscape in terms of existing habitat retention, modification or biodiversity values across. Different management conditions could then be applied in these different management zones.

4.3.1.3 How should the local landscape conditions be applied – Roving windows or discreet local landscapes?

The advantages and disadvantages of different ways of applying the local landscape conditions are provided in Table 5. The best option will depend on ecological and practical considerations. Fixed boundaries may be easier for auditing and potentially long-term planning, but can lead to complexities if on-ground harvest boundaries change. However, if a harvest boundary crosses two local landscapes, it is possible to consider the two planning boundaries separately. Roving boundaries can help prevent perverse outcomes (e.g. if harvested areas are on the same boundary in adjacent local landscapes then the area of impact could be much larger than intended or expected). However, if a 'gap' analysis is done at a finer scale, as suggested above, this would help reduce the risk of perverse outcomes when using fixed boundaries. For either fixed or roving boundaries, but especially for roving boundaries, it will be important to record exactly how the assessment areas are selected and ensure there are effective controls against bias. In general, the fixed window approach is probably the most transparent method that will help with planning certainty and ease of audit while still providing good ecological outcomes if appropriate checks are used.

4.3.2 Maximum disturbance threshold within a local landscape

4.3.2.1 Is a threshold for the maximum % of area harvested in a certain timeframe a good idea?

The maximum threshold for intensive harvesting in the local landscape would replace the current TSL approach which limits the basal area that can be extracted within a harvest unit (40%). The latter is impossible to measure and hence audit in a practical sense. The proposed disturbance threshold is potentially less ecologically relevant (in that arbitrary thresholds will need to be defined that may not be related to natural basal areas of the forest), however it should be easier to implement and audit (Table 6).

4.3.2.2 Are the amounts appropriate? Is the variation with intensity suitable? Is a 5yr period a good idea or would linking to regeneration state be better?

It is difficult to provide comment on an appropriate maximum % of area harvested threshold. Where harvest area limits are applied in other areas they tend to be less than 260 ha, and are frequently much less than 100 ha (McDermott et al. 2007) and these are often applied across the forest estate in conjunction with a dispersal rule. Consideration should be given to how the harvest area limit would be applied – dispersed or aggregated. The proposed new approach is focused on the area harvested and so it cannot, by definition, take account of the retained areas. To be effective the threshold needs to take into account the realistic and practical trade-off between conservation and economic activity.

In NSW, most harvesting is currently done using relatively low intensity silviculture (J. Williams, pers. comm.). However, the frequency of successive harvest events can be high in a particular area so the intensity may be relatively high over time. Furthermore, high intensity silviculture can be used and markets can change, which means the future direction of silvicultural regimes in NSW is not fixed. Therefore, any approach adopted needs to consider the potential for intensive silvicultural practice in the future.

Table 4. Advantages and disadvantages for different approaches to retention, including practicality and impacts on biodiversity.

Approach	Advantage	Disadvantage	Comments
Minimum retention – unspecified composition	• Easy to implement. • Easy to audit. • Helps cater for unknown ecological values.	• Uncertainty in the ecological values being retained. Additional measures and retention may be required for threatened species or other values (e.g. mature forest).	• Likely to be OK if repeated across the landscape, but need to monitor to check that objectives met.
Minimum retention - targeted composition	• Guarantee protection for target value. • Has the potential to help recruitment of ecological values. • Potentially easy to implement relevant information available.	• Need to have relevant spatial layers to facilitate strategic planning. • More difficult to audit, depending on the values being targeted. • Requires prioritisation of different values. Some values could be under-protected.	• Need processes in place to identify if areas identified on the ground and retained don't match areas mapped for particular values.
Variable levels of retention – targeted composition	• Focuses retention where it is expected to best capture the values needed for threatened species. • Maximises the area available for harvesting, within the constraints of threatened species management. • Has the potential to manage all the special values if there is no upper limit on the area that can be retained.	• Does not cater as well for unknown ecological values, as does not ensure retention across the estate, is biased towards threatened species or particular values. • Requires adequate information on species ecology and distribution to be implemented effectively. • Can potentially have a large impact on the area available for harvest in some areas (e.g. in the range of a particularly sensitive threatened species).	• Need adequate information on species ecology and distribution. • Need to train planners to identify and manage for priority ecological values.
Maintain a target level of the harvested area within a specified distance of intact forest	• Easy to audit. • Potentially easy to implement. • Helps ensure minimal 'gaps' in the retained canopy.	• Does not guarantee the amount of habitat to be retained, which has frequently been shown to be important for species persistence. • Potentially has an impact on the area available for harvest. • Issues with maintaining intact edges.	• Potentially less ecologically relevant for low-intensity silviculture.

Table 5. Summary of advantages and disadvantages of different ways of applying the local landscape conditions.

Approach	Description	Advantages	Disadvantages	Comment
Pre-defined area (e.g. compartment)	This would involve defining the management boundaries *a priori*, and using these over time regardless of changes in harvest boundaries.	• Simple for long-term planning. • Easy to audit.	• Ecologically less meaningful, because 'gaps' may form in the landscape. • Harvest operation boundaries may change to cover more than one management unit, which would make planning more complex.	• If harvest boundaries change to cover to multiple management boundaries (e.g. compartments), planning would have to be done in two parts to ensure the requirements of the two management units are met. • Would need to have some sort of 'gap analysis' to prevent perverse outcomes.
Fixed area and shape – roving window	For example, apply a circular management boundary centred on the harvest area.	• Standardised area that can be set to be ecologically meaningful. • Ecologically meaningful, as it considers the amount and distribution of habitat around the operation, and is not defined by arbitrary boundaries. • Potentially takes account of habitat available on other land tenures (e.g. CAR reserves).	• Potentially harder for long-term planning and landscape-scale assessments and audits. • Having private land or other tenures not managed by FCNSW could be problematic. The security of the habitat in these other land tenures may or may not be guaranteed.	• Could include areas that are not subject to management in the assessment (e.g. private land, formal reserves) (ecologically more meaningful) or not (potentially more practical as this considers only areas available to be managed and there is more certainty in long term).
Fixed area, variable shape	A pre-defined area of assessment, but the user is free to define the shape that area can take.	• User flexibility. • Potentially easier to achieve wood production targets. • Difficult to audit.	• The same retained areas could be used for multiple operations, and so the landscape goals may be at risk of not being met in practice.	• A clear system for reporting how assessment areas were selected and defined would be required.

Forest types differ in their natural basal area, and in NSW most forests range from 20–50 m^3/ha (J. Williams, pers. comm.). If the maximum % of area harvested threshold is to be adjusted for different intensities of logging then the categories of logging intensity would need to be defined according to minimum basal area retained. From an ecological perspective this basal area threshold should vary between forest types which have different ecological and regeneration/successional characteristics, natural densities and disturbance histories, but having multiple thresholds would make the planning process complex.

Having a five year time-frame is a practical approach in that it is easy to implement and audit. However, it will be important to monitor regeneration and assess if, as a minimum, understorey cover has returned within this time frame.

4.3.2.3 What is acceptable extent and intensity of harvesting in local landscape scale (1500 ha)? Roving window versus forest harvest area?

There is no 'correct' answer to this question. These values should be established by considering the ecology of the species in the area and practical and economic constraints. The proposed local landscape (1500 ha) is very large. If the maximum harvest area is only limited at this scale, a large maximum harvest area threshold would presumably be needed in order to maintain current levels of production. The approach would therefore not be very effective at dispersing harvesting, except within the broader landscape which will be relevant to some species but not others. The effect of this will depend on the intensity of harvest. Therefore it may be more appropriate to manage the spatial dispersion of harvesting at a smaller spatial scale within the 1500 ha local landscape or instead of the 1500 ha scale. A different local landscape could be defined for applying the maximum harvest threshold, or a 'gap' analysis could be done before harvest to ensure that dispersal objectives (for soil and water and to some extent biodiversity) at a finer spatial scale are being met.

Another option would be to apply a 'roving window' around all harvest operations within the local landscape, and limit the harvested area in that window. A 'roving window' is one of the more ecologically meaningful management boundaries, as it is not based on an arbitrary land tenure boundary but takes into account the characteristics of the landscape around the operation. Roving windows may be more difficult to implement and regulate than fixed boundaries, but they will help prevent undesired outcomes such as two adjacent areas in different management units being logged simultaneously. Furthermore, roving windows enable excluded areas such as formal and informal reserves, as well as intensity of harvest, to be taken into account when applying the maximum % of area harvested threshold. A roving window could be used in addition to the proposed 1500 ha local landscape.

The proposed approach appears to only address high intensity silviculture and does not take into account any less-intensive silviculture occurring in the surrounding area. It therefore potentially allowing a higher level of impact and is less effective at dispersing harvesting.

If the proposed approach is adopted, we suggest that it should be accompanied by additional constraints on adjacency of harvest operations to more effectively disperse harvest operations. Another alternative would be to give each of type of silviculture a 'weighting' according to the average proportion of the basal area that is harvested. A simple formula could be developed where areas harvested by the different types of silviculture are multiplied by their respective weightings, the values are summed and the final value informs whether the area threshold has been exceeded or not. This type of formula, while potentially being difficult to develop, would consider all harvesting in the area not just the higher intensity silviculture. Larger areas could be harvested by lower intensity silviculture, and smaller areas harvested by higher intensity silviculture, or a combination of both.

Another alternative for managing the landscape is to combine the habitat retention and maximum harvest area thresholds and manage for stand age structure. Managing stand age structure would help ensure some areas are managed for long term retention and limit the amount of harvesting in that landscape. However, it would be challenging to develop a flexible and appropriate stand age structure management matrix.

Table 6. A summary of the differences between the current and proposed approach for dispersing harvest operations.

Issue	Current approach	Proposed approach
Ecological relevance	The approach adjusts to the basal area of the forest type.	Thresholds will need to be defined to classify 'intense' harvest events, there will be limited capacity to vary this threshold between forest types and forest structures.
Ability to promote spatial dispersion	Limits spatial extent to a variable level, depending on the size of the harvest area. Potentially large areas could be intensively harvested using this approach. No area limits for low intensity silviculture.	Limits spatial extent to a pre-defined level, but only for intensive operations. No area limits for low intensity silviculture.
Ability to promote temporal dispersion	Applies a 5 year interval between harvests.	Applies a 5 year interval between harvests.
Flexibility	Range of silviculture can be employed.	Range of silviculture can be employed.
Complexity to implement	Potentially more complex, as need to have a clear plan prior to harvest and monitor basal area and/or extraction as it occurs.	Relatively easy. Need to monitor basal area if approaching the threshold.
Ability to audit	Difficult to do pre-harvest audit so reliant on looking at stumps and examining basal area retained.	Relatively easy. Assess basal area of retained area and size of harvested area.

Table 7. Advantages and disadvantages to different approaches to managing the spatial and temporal impact of harvesting (note: some of these measures can be used simultaneously).

Approach	Advantage	Disadvantage	Comments
Upper limit on the area of harvesting	• Will help manage scale of impact at the scale at which management is applied. • Thresholds are clear, easy to understand and therefore apply. • Thresholds are easy to audit.	• This approach does not guarantee the full range of seral stages will be maintained, so this measure alone does not ensure spatial dispersal. • Difficult to establish a meaningful management scale. • Simple thresholds can sometimes lead to perverse outcomes. • Potentially only considers some types of silviculture (i.e. this is often only applied to high intensity silviculture). Would need to establish complex weighting model if this measure is to consider all types of silviculture.	If this approach is applied using spatial information, it is critical that spatial layers are kept up-to-date and a record is kept of the areas that have been harvested. To help ensure spatial dispersal this measure should be applied in conjunction with the adjacency prescription.
Upper limit on basal area to be harvested	• Will help manage scale of impact at the scale at which management is applied. • Thresholds are clear, easy to understand. • The intensity of harvesting will vary according to type of silviculture and density of original forest type.	• This approach does not guarantee the full range of seral stages will be maintained, so this measure alone does not ensure spatial dispersal. • It is difficult to establish a meaningful threshold. • Impossible to measure and hence audit in a practical sense.	Better expressed as minimum level of basal area retained, which is easy to measure. If this approach is applied using spatial information, it is critical that spatial layers are kept up-to-date and a record is kept of the areas that have been harvested. May need to consider adjacency of harvest operations to ensure spatial dispersal of harvesting.
Geographic separation of harvest operations	• The ecological relevance of this approach depends on how it is	• The degree to which this measure helps disperse harvest operations depends on the	Works more easily for smaller coupes than larger operations.

Approach	**Advantage**	**Disadvantage**	**Comments**
(adjacency)	applied. Applying an adjacency constraint to a maximum area is potentially more meaningful than applying adjacency constraints regardless of the size of the harvest unit. • Easy to audit. • Easy to understand and therefore apply.	size of the harvest unit and other measures that are in place. Research indicates more frequent less intensive harvesting may be better than less frequent more intensive harvesting.	Need to define what is 'adjacent'.
Using time to separate harvesting (e.g. five years)	• Easy to understand and therefore apply. • Easy to audit.	• Less ecologically meaningful than relating management to regeneration success directly. To be meaningful the time frame needs to be such that adequate regeneration is guaranteed, to a level that achieves its objective (e.g. maintain cover or maintain habitat).	The validity of using a time period (five years) as a surrogate for regeneration success would need to demonstrated (e.g. through regeneration audits and effectiveness monitoring).
Using regeneration level to separate harvesting (e.g. by height of regeneration)	• Easy to understand. • More ecologically relevant than using a time frame. • Easy to audit.	• More difficult for strategic planning.	The ecological validity of using the regeneration stage selected (e.g. height) would need to be demonstrated through effectiveness monitoring.
Manage a pre-specified seral stage pattern	• Could potentially help maintain stream flow as well as habitat for threatened species. • Ecologically meaningful.	• Difficult to establish a practical and meaningful management strategy. • The scale at which this would potentially be applied (e.g. catchment) may differ to other management. • Requires more complex information to adequately plan and implement.	While this approach is potentially the most ecologically meaningful, it has logistical difficulties which means it is rarely applied in practice.

4.3.2.4 Comparison of approaches for dispersing harvesting in time and space.

Dispersed harvesting seems preferable for the majority of sensitive species or for areas subject to disturbance events (4.1.2). Applying a maximum area that can be disturbed within a specified time frame is one step to helping achieve this (Table 6). Alternative approaches are preventing harvesting of 'adjacent' areas, or targeting a seral stage pattern in the landscape. An evaluation of the pros and cons of each approach, in terms of how effective they are, how easy they are to implement and enforce techniques are provided in Table 7. A common technique is to have both a maximum area of impact and adjacency restrictions, but these are generally only applied to high intensity (clearfall, seed tree retention) operations.

To our knowledge, greater focus is given to the dispersal of high intensity silviculture than low intensity silviculture. This is defensible, because the impact of harvesting on sensitive species generally increases with the intensity of the silviculture. The basal area at which silviculture is classified as 'high intensity' should consider the sensitivity of the local species. It might be argued that consideration should be given to dispersing low intensity harvesting as well through the TSL. However to do so requires careful consideration to ensure there are no perverse outcomes. Reducing the level of harvesting in some areas can increase the level of harvesting in others, with detrimental outcomes.

4.3.3 Key points

The results of our review indicate that these 'local landscape' conditions, when implemented in combination with the full suite of conditions in the TSL, should meet the desired outcome and contribute to the multi-spatial scale approach. Key points for the minimum retention condition are –

- The level of retention will make a reasonable contribution but its effectiveness needs to be monitored and additional targeted retention may be required in some areas.
- Guidelines are needed for selecting areas for retention and a process for 'moving' retained areas or 'managing' retained areas.
- The size of the retained area will need to take into account the realistic and practical trade-off between conservation and economic activity.
- 1500 ha is considered appropriate for mid-scale management, but a gap-analysis would be needed to protect against perverse outcomes.
- Fixed boundaries may be easier for auditing but roving boundaries may be more ecologically sensible.

Key points for the maximum harvest area condition are –

- The definition for the local landscape is supported due to the benefits it has for 'landscape-scale' planning. However, the proposed size is probably too large to use as a limit for the maximum harvest area, and a gap analysis would be required to determine if the retention levels are achieving the goals of landscape planning (e.g. in terms of connectivity and heterogeneity).

- Consider using an alternative, or additional smaller planning scale for applying the maximum harvest area condition.
- Consider including an 'adjacency' prescription to complement the maximum harvest area and help ensure spatial dispersion of harvesting.
- Consider assessing the area harvested by all types of harvesting when applying the maximum area threshold, e.g. by applying a weighted formula.
- Monitoring is required to determine the effectiveness of this approach.

5 Individual tree retention measures

5.1 Proposed condition for the TSL

The proposed 'outcome' or objective for the local landscape conditions in the revised TSL (EPA et al. 2013) is " minimum thresholds of hollow-bearing trees and recruitment and feed trees to be met at a local landscape scale to ensure adequate shelter and food resources are maintained or enhanced for threatened fauna species".

The concept is - A minimum of 5 habitat trees (where available), 5 recruit trees and 5 feed trees per hectare within the net operation area will be retained undamaged by the operation or post-harvest burns at 2 years after the completion of the operation, or in any subsequent operations.

Information to address the queries raised by the NSW team (Table 1) in relation these conditions is provided in this section.

5.2 Brief review of relevant information

Live trees are retained to provide habitat for biodiversity in harvested areas in many areas of the world. The three main objectives of 'green-tree retention' in the literature are: (1) to ensure continuous occupancy of the harvested area through providing 'lifeboats' for species and processes over the regeneration phase (2) to ensure the continued presence of specific microhabitats that can be inhabited after or during some suitable period by enriching re-established forest stands with structural features, and (3) to facilitate the ability of the species to disperse throughout the harvested landscape through enhancing landscape connectivity (Franklin et al. 1997, Rosenvald and Lohmus 2008). Such trees can be selected for particular features (e.g. hollows) or based on diameter or species. They can be included as part of the silviculture (e.g. seed tree retention) or can be additional retention.

5.2.1 Use of retained trees by fauna

A considerable amount of research shows that retaining trees in the harvested area is beneficial for biodiversity, although not all species will use individual trees retained within harvest areas. A review in North America found that green tree retention is particularly beneficial for fungi, lichens, and small ground-dwelling animals in the harvested area, but further measures are required for bryophytes, vascular plants and saproxylic species (Rosenvald and Lohmus 2008). As structural elements, the trees were particularly beneficial for insects and birds, but were less commonly used by mammals (Rosenvald and Lohmus 2008).

Although beneficial for many species, retaining trees within the harvested area alone will not maintain all species in harvested landscapes. Not all species will use the retained area immediately, but some species will begin using these retained trees over time as the stand regenerates (Rosenvald and Lohmus 2008, Cawthen and Munks 2011).

The spatial distribution and rate of retention can influence which species will use retained trees. Forest interior species are unlikely to be maintained unless trees are retained in very large patches. In North America it was found that retention of less than 20% of the growing stock had negligible benefits for many species, and that at least 9–15 m^2/ha was required to help maintain vertebrates of conservation concern (Rosenvald and Lohmus 2008). However, even isolated trees in heavily modified areas can be important for some species (Gibbons and Boak 2002), so any level of retention will be beneficial for some species.

5.2.2 Rate of retention

Required rates of retention can be defined by legislative tools, or promoted by certification bodies (Gustafsson et al. 2010). However, determining a suitable rate of tree retention is not easy. The rate and type of retention required ideally needs to consider the objective of the retention (and therefore potentially the ecology, density and diversity of species that may use the trees), post-cut mortality of trees, and recruitment of trees over time. The requirements may also consider other measures that are in place to ensure retention across the landscape. Rates of retention required in Australia differ between states, forest types, and whether they are in the range of particular threatened species or not (Table 8). Most, but not all, regions also specify the number of recruitment trees required to perpetuate hollows over the long term. In order to ensure a perpetual supply of hollow-bearing trees a greater number of recruitment than habitat trees may need to be retained (Gibbons et al. 2010), although this is not always reflected in management prescriptions (Table 8).

A number of studies have estimated the rate at which trees are used or need to be retained (Table 8). There is considerable variability but up to 57% of hollows and hollow-bearing trees have been shown to have evidence of use by fauna in Australia (Gibbons and Lindenmayer 2002) (see Box 2 for a summary of some studies in NSW). In many areas the number of trees to be retained is lower than the rate estimated they are needed by fauna. Only rarely is any difference in use and retention explained, generally occurring as a result of balancing economic and environmental considerations (Lamb et al. 1998). However, not all trees retained necessarily possess the required attributes (e.g. hollows suitable for use by fauna) so the rate at which trees are retained can differ from the rate at which trees useful for fauna are being retained (Koch et al. 2008).

Box 2. Estimated rate of tree use in NSW

- SE NSW: mean 22.7 trees per ha with large hollows in tall, montane forest (Kavanagh 1987).
- NE NSW: 6–13 med-large hollows & 12–27 small hollows/ha, upper limits in high quality sites (Smith 1993). This requires 6–13 habitat trees/ha (Lamb et al. 1998).
- N NSW: Few arboreal marsupials when <3 HBT/ha (Mackowski 1984). Peak in arboreal marsupial abundance when >30 HBT/ha (Smith and Murray 2003).

5.2.3 Selection of trees

Trees are generally selected for retention by the presence of hollows, tree form or tree size (Table 9), although in some areas tree species is also important (Rosenvald and Lohmus 2008). All these values are ecologically relevant, even in relation to hollow availability. However, the relationship between tree size and hollow availability can vary between species (Gibbons and Lindenmayer 2002, Fox et al. 2008). There are different advantages and disadvantages in how trees are selected for retention (Table 11).

5.2.4 Spatial configuration

Retained trees can be evenly distributed across the harvested area, aggregated or clumped. In the review conducted in North America, the spatial arrangement of trees was of lesser importance than the rate of retention (Rosenvald and Lohmus 2008). However, in general aggregated retention is considered to be advantageous over dispersed retention for many, but not all species (Rosenvald and Lohmus 2008). Advantages of clumped retention include reduced mortality, retention of understorey species and values such as coarse woody debris, creation of non-edge areas and logistical considerations (Gustafsson et al. 2010). Inter- and intra-specific competition can affect whether clumped or dispersed retention is ecologically preferable. Being too prescriptive about the spatial configuration of retained trees can result in perverse outcomes, as the target values for retention may not conform to the specified spatial configuration (Munks et al. 2004).

5.2.5 Mortality

In order to achieve their objective, retained trees have to persist in the harvested area for a long period. Trees can be more likely to collapse if they have incomplete crowns, are hollow-bearing, have fire scars, and are away from intact edges (Gibbons et al. 2008). Site attributes that can affect tree mortality include aspect (which can relate to wind speed or fire intensity), soil depth and moisture, and basal area of retained trees (Gibbons et al. 2000). It has been suggested that choosing the healthiest trees, protecting them from fire, and retaining them near or among other trees will help their survival (Gibbons et al. 2008). Regardless of the precautions taken, retained trees will collapse over time. It is therefore recommended that the number of trees retained is more than the minimum number required (Gibbons et al. 2008). In Sweden, the legislation states that trees should be retained in a way that will amount to at least 10 old, large, live trees in the next forest generation (Gustafsson et al. 2010).

Table 8. Rates of retention of hollow-bearing trees (HBT) and estimated rates of use by fauna

Location	HBT	Recruit	Retention measure	Estimated rate of tree use by any or all vertebrate fauna
Tasmania	0.3	0.3	Clearfall operations: Patches (approx. 50 m × 20 m) containing at least 2–3 habitat trees retained every 200 m along harvest boundary (unless within 200 m of reserved area) = approx. 0.3 trees/ha. Partial harvest: Patches (0.09 ha) containing at least 2–3 habitat trees retained every 5 ha (only for areas more than 200 m from edge of harvest operation) = approx. 0.3 trees/ha.	All species: 10–15 trees/ha (wet *E. obliqua* forest) and 8–12 trees/ha (dry *E. obliqua* forest) (Koch et al. 2008).
Victoria	1–20	0–20	Varies with region and forest type from 1 to 20 trees/ha and 0 to 20 recruits per hectare. Often indicated as specified diameter trees.	E Vic: ~10 suitable hollows/ha needed for 9 species (Menkhorst 1984). Central Vic: 16 to 24 hollows/ha needed for 13 species (Calder et al. 1979, cited by Menkhorst 1984). SE Vic: 7–14 trees/ha showed evidence of use by 46 species (Gibbons 1999).
Western Australia	0–5	0–8	Jarrah: 5 primary trees per hectare, 6–8 secondary trees. Karri: no primary trees in adjoining informal reserve, 2 secondary trees. Mixed karri/jarrah forest: 5 primary trees and 2 secondary trees/ ha except in clearfall where marri has been retained. Immature even-aged stands: no retention.	Insufficient data available (Whitford and Stoneman 2004).
Queensland	2–6	1–2	Coastal wet/coastal moist hardwood, coastal/inland dry sclerophyll in greater glider range: 6 live HBT/ha and 2 recruit. In coastal/inland dry sclerophyll outside Greater glider range: 4 live HBT/ha and 1 recruit. In inland cypress: >2 live HBT/ha (where available) and 1 recruit, and keep additional recruits if no HBT.	Dry sclerophyll forest: 7.2 trees/ha. Moist coastal hardwood forest: 5.5 trees/ha. Wet coastal hardwood forest: 8.2 trees/ha (Smith and Lees 1998). SE Qld: all 6 arboreal marsupial spp. only found when ≥4HBT/ha

Location	HBT	Recruit	Retention measure	Estimated rate of tree use by any or all vertebrate fauna
				(Moloney et al. 2002).
Sweden	Variable (10*)		In legislation older trees must be left standing, preferably in groups. Under FSC certification need to retain all stags, windthrows and other trees that have been dead for more than a year. Retain at least 10 old, large, live trees in the next forest generation, prioritise high biodiversity value trees. Under PEFC certification set aside live conservation trees (deviating, old, large diameter, deciduous, hollow trees etc) that amounts to 10 trees per hectare (Gustafsson et al. 2010).	
Norway	5 (10*)		In legislation need at least five retention trees per hectare, preferably in groups. Under PEFC certification need an average of 10 trees per hectare retained (min dbh 20 cm) including trees with high biodiversity value (Gustafsson et al. 2010).	
Finland	0 (5*)		No retention required by legislation, although some measures to retain large, solitary trees. Under PEFC certification need to leave stags, windfalls, and at least five retention trees (dbh >10 cm) per hectare, including trees with high biodiversity value (Gustafsson et al. 2010).	
Washington & Oregon, USA	10–25		Federal land, mature forest: retain green trees in at least 15% of the area in each harvest unit, and 70% of this must be in aggregates 0.2–1.0 ha or larger, with the remainder dispersed either as single trees or in small clumps less than 0.2 ha in size. Retention should, where possible, include the largest and oldest live trees, decadent or leaning trees and hard snags (Aubry et al. 2009). Public land: 20–25 trees per ha + 2 logs retained in regeneration harvest areas, retained trees must be within 100 m of a mature forest edge or other retained trees (Gustafsson et al. 2012). Private land: 10–12 trees per ha + 2 logs retained in regeneration harvest areas, retained trees must be within 300 m of a mature forest edge or other retained trees (Gustafsson et al. 2012).	

Table 9. A summary of how habitat and recruitment trees are selected in Australia.

Region	Habitat trees					Recruitment trees			
	Visible hollows	**Tree diameter**	**Tree senescence**	**Tree form**	**Other**	**Visible hollows**	**Tree diameter**	**Tree senescence**	**Tree age**
SW WA	Present, or broken stubs with potential to develop hollows	>70 cm	Moderate to high		Avoid lean trees, hollow-butts and termites, no tree species preference	Potential to develop	30–70 cm	Moderate	Karri forest: 40–80 yr
Tasmania	Present	Use[a]		Mature		Potential to develop			
Victoria		Use (variable)[b]					Use (variable)		
Queensland	Multiple present, one with >10 cm entrance	>80 cm	Healthy crown	Dominant/ co-dominant	Have fissured bark, mistletoe and epiphytes, consider spacing		Use	Use	
Oregon, USA (type 2 and 3 harvest units)		>11 inches dbh		>30 feet tall	At least half must be conifers				
Sweden		Not specified		Alive					
Finland		10 cm		Dead or alive					
Norway		20 cm							

[a] 'Use' indicates the prescriptions mention this attribute should be considered but no details are provided as to cut-offs.

[b] 'Use (variable)' indicates that the size limits used varies between forest types.

Table 10. A summary of the prescriptions relating to the spatial configuration of retained hollow-bearing trees within harvested areas.

Region	Configuration prescriptions
SW WA	Dependent on where the most appropriate trees are situated within the coupe. Small groups of primary and secondary habitat trees are preferred.
Tasmania	Consideration given to tree location and potential damage from harvest activity. Clearfall operation: clumps every 200 m along coupe boundary. Partial harvest: clumps throughout harvest area.
Victoria	Some direction in Central Gippsland and Central ash forests.
Queensland	Under standard harvesting practice, where habitat trees are provided uniformly on harvesting areas, additional recruitment trees must be retained according to Table 3 where >50 percent of the basal area of the stand is to be removed. Where the required numbers of these additional trees are not available in a particular size class, trees must be retained in the size class below at a rate of 1.5 trees for every tree below the required number (or round up if the number is a fraction).

5.3 Comments on the proposed approach and response to queries

The rate of retention currently proposed in NSW is 5 habitat trees, 5 recruitment trees and 5 feed trees. This is in the middle of the range of the retention rates found elsewhere (Table 8), and is at the lower end of the range at which trees are recommended for retention in NSW (Box 2). However, other conditions will also contribute to maintenance of habitat tree and feed tree availability, such as the 20% minimum retention condition. While the minimum retention condition is not targeted to capture particular features, it is likely that these retained areas will capture older trees and feed trees. Monitoring is required to determine if the individual tree condition combined with the local landscape conditions are effective in meeting the desired outcome.

The rate of tree retention proposed for the revised TSL is relatively simplistic in terms that only a single rate of tree retention is specified for all forest types. This simplicity makes the approach easy to implement and audit, but does not account for the variability in tree density or fauna requirements between forest types.

The current approach seems to focus on single tree retention. The benefits of using a single tree retention prescription include facilitating recolonisation of some species, helping retain higher levels of suitable trees if they are at low densities, and it is easy to audit. However, single tree retention prescriptions also have their limitations. In many areas, the tree retention prescriptions alone are unlikely to meet the requirements for hollow-using fauna (Lamb et al. 1998, Koch et al. 2008), and not all species will utilise isolated trees, at least in the short term (Cawthen and Munks 2011). Isolated trees can be subject to high rates of collapse due to windthrow or other factors than trees retained in clumps (Duhig et al. 2000, Gibbons et al. 2008). Single tree retention is not practical for some types of more intensive silviculture (e.g. clearfell-burn and sow) and not all areas will have the prescribed rate of suitable trees (Munks et al. 2004). Finally, it can be difficult to identify suitable hollow-bearing trees (Koch 2008, Koch et al. 2008, Stojanovic et al. 2012).

An alternative to retaining individual trees is to retain trees in patches. Research has shown there are many benefits to retaining trees in clumps, but for some species dispersed retention is better. Areas in Australia differ in whether they maintain single trees or patches in production forest areas (Table 10), but all areas currently manage these features at the scale of the harvest unit. It is possible to take a landscape approach to the management of features such as tree hollows, as long as suitable spatial information is available. Retention of patches of suitable habitat throughout the landscape mean areas with the highest quality and density of habitat can be maintained. Patch retention does not necessarily promote recolonisation of harvested areas by fauna, but can help maintain populations of species in areas utilised for wood production. If a landscape approach is not possible due to a lack of suitable information, patch retention can occur within the harvested area by combining the individual tree condition with the habitat clump condition. Given the diverse requirements of species, a mixture of aggregated and dispersed trees may best meet the needs of different taxa. Therefore retaining at least some of the target trees in habitat clumps, as long as they are suitable trees, will help meet the intended ecological outcome of this licence condition.

If a tree is not of adequate ‘quality’, it will not achieve its objective of providing habitat for fauna, although it may do so over time. There is variation across Australia in how habitat trees are selected for retention (Table 9). Identifying suitable trees from the ground is very difficult, but looking for visible hollows will provide the most certainty that the trees are likely to contain a hollow suitable for use by fauna (Table 11). However, looking for hollows is time consuming, requires practice, is difficult in some forest types, and it is very difficult to audit how well the trees are being selected as audits are generally done after harvesting. Therefore many areas focus on other attributes of the trees as well, for example by selecting trees according to their diameter. Selecting trees by diameter has many advantages, in that it is a standardised technique, it is measurable and easy to audit and it is strongly related to hollow availability. One disadvantage with selecting trees by diameter alone is that tree species differ in their growth rates and their propensity to form hollows. If trees generally grow in single species stands, this factor is not an issue. For multi-species forest stands, this can make the outcome more problematic. If tree selection in multi-species stands is based on tree diameter alone, it will be important to confirm that the trees selected do produce hollows that are useful to fauna. An alternative option is to select the largest or oldest trees, by tree species, meaning the species of trees being retained should reflect their relative availability in the landscape. However, this approach can also be difficult to audit because it can be difficult (or impossible) to identify tree species from cut stumps. Another option is to select trees based on their size, and ensuring the slower-growing but hollow-bearing species are selected for recruitment trees.

Both dead and live trees can provide suitable habitat for fauna. There is some debate about whether the insulating properties of tree hollows vary if the tree is dead or alive, but both dead and live trees will be used for shelter by fauna. One of the limitations of using dead trees for retention is that they are less likely to persist in the landscape, being more prone to collapse. Therefore while retention of dead trees should be encouraged, tree retention measures should primarily target live trees to help ensure continuity of the resource.

Table 11. Advantages and disadvantages of different approaches to selecting trees for retention

Selection attribute	**Advantage**	**Disadvantage**
Hollow availability	• Directly assessing the attribute to be managed (even though there are errors in detection).	• Requires detailed survey, which could be open to error. • Difficult to audit.
Diameter	• Easy to audit. • Easy to assess in the field. • Strongly related to hollow availability (although it is an indirect measure).	• Does not cater for variability in hollow formation between tree species/growth rate.
Diameter in relation to tree species availability	• Easy to assess in the field when planning.	• May be difficult to audit if tree species cannot be identified from the stumps.
Form	• Reflects likelihood of hollow availability without relying on detailed hollow assessments.	• Needs training to assess appropriately, and there can be a high level of subjectivity. • Potentially difficult to audit.
Age (e.g. from oldest cohort)	• May be difficult to audit.	• Can be difficult to determine if species have different growth rates.

Tree diameter and form, and location in the landscape can be useful attributes when selecting recruitment trees. The intent should be that recruitment trees are from the next age cohort younger than the habitat trees, and should be robust trees located in protected areas so they are likely to persist in the landscape over the long term. The current number of recruitment trees specified (5) is probably too few to maintain the stated number of habitat trees (5) over the long term. Therefore if there are insufficient habitat trees to meet the target level, this number should be made up of recruitment trees instead.

5.3.1 Key points

- When combined with other conditions (e.g. minimum levels of retention) these are likely to contribute to the management of habitat for hollow-using species. It will be important to monitor the effectiveness of this approach.

- It is possible to take an area-based landscape approach to the management of mature trees, but this approach requires suitable spatial information.

- Determining the most appropriate method for selecting trees to be retained depends on the relative emphasis placed on short and long term ecological outputs, ease of implementation and auditing. One option would be to select trees according to size, but targeting slower-growing species that are prone to forming hollows as recruitment trees.

6 Habitat clumps/patches

6.1 Proposed TSL condition

The proposed 'outcome' or objective for the habitat clump condition in the revised TSL (EPA et al. 2013) is "patches of undisturbed forest (wildlife habitat clumps) will be retained within the harvestable area to retain a variety of undisturbed/undamaged habitat elements representative of the site and enhance recolonisation of areas following harvesting".

We interpret the intent of the habitat clump condition as being (1) to capture features and habitat not addressed by other measures and (2) to help promote connectivity within the harvested area and (3) to help promote recolonisation. The habitat clump condition does this by trying to capture the range of habitat types present, and by applying the clumps at specified distances from the harvest boundary in intensive harvest operations. The habitat clump conditions help replace the previous conditions relating to minimisation of disturbance to the understorey.

Under the proposed approach habitat clumps only need to be applied in intensive operations (the suggestion is for basal areas less than $15m^2$). Habitat clumps can be based around trees retained as part of the individual tree requirements or other landscape features (e.g. rock outcrop), but it is proposed that only 2 trees per clump can contribute to the individual tree retention requirements. The proposed minimise size of the habitat clumps is a ten metre radius (i.e. 0.03 ha). It is proposed that clumps are retained at a rate of one per hectare, but only in areas more than 100 m away from the mapped protection areas. It is currently recommended that habitat clumps must be dispersed across the net harvestable area, with a minimum of 50 m and a maximum of 150 m between clumps.

Information to address the queries raised by the NSW team (Table 1) in relation these conditions is provided in this section.

6.2 Brief review of relevant information

See Section 4.2 for an overview of the benefits of retaining patches of forest for biodiversity.

6.3 Comments on proposed approach and response to queries

Retaining patches of forest in harvested areas has clear benefits for biodiversity. However the size, spatial distribution and composition of these patches will influence the species that use these patches, and therefore the effectiveness of this management approach. Three elements (sub-objectives) were identified in the outcome of the habitat clump conditions.

One sub-objective of the proposed approach is that habitat clumps should help capture features and habitat not captured by other measures. The current measures do not seem to target particular values, but may target different vegetation communities present within the harvested area, so it is uncertain how well this sub-objective will be achieved. The proposed habitat clumps are very small and may be heavily edge-effected. Edges can influence the microclimate for a distance into the clumps, which can affect the health and composition of the vegetation. Edge effects may therefore impact how effective the current habitat clump provisions are for maintaining understorey diversity and composition. Clumps may also be based around habitat or feed trees and the presence of clumps should increase the longevity of these features, although the small size of these clumps means it is uncertain the degree to which clumps will minimise tree loss. Therefore the effectiveness of this licence condition is likely to depend on the value being managed. Guidelines will need to be developed that make it clear which features are being managed by this approach. These guidelines should not be overly prescriptive as not all areas may have the target features, but they will facilitate implementation and monitoring of this licence condition.

How effective habitat clumps are in facilitating recolonisation will probably also depend on the size, composition and location of the clumps. If the understorey species in the clumps are not strongly edge effected, then the clumps may help provide a seed source for recruitment of understorey species. Monitoring is required to determine if the habitat clumps are effective in promoting recolonisation, and by which species.

The proposed approach specifies the dispersal of clumps throughout the harvested area to enhance connectivity. Larger clumps can be used by a greater diversity of species, and provide greater protection for some values (e.g. retained trees). Therefore, it may be more beneficial to aggregate clumps in circumstances where connectivity is a priority. An understanding of the effectiveness of the habitat clumps is needed before strong conclusions can be drawn about whether it is preferable to disperse habitat clumps or aggregate them. With this in mind, it may be better to avoid being overly prescriptive about how habitat clumps should be distributed until the effectiveness of the clumps is better understood.

Under the proposed approach habitat clumps would only be implemented during intensive operations. This is defensible because the proportion of species impacted by harvesting can increase with the intensity of the harvest. Therefore the need for additional measures to promote recolonisation will be greater in more intensive operations. However, some species can be impacted even by low intensity silviculture, so applying habitat clumps even in these areas may be beneficial for some species. Furthermore, it may be difficult to establish an appropriate basal area at which habitat clumps should be applied, as basal areas vary between forest types.

The proposed approach specifies that habitat clumps are only required at a specified distance from an unharvested edge. This is sensible as the retained areas will provide intact habitat that should help meet the objectives of the habitat clump provisions. As the distance to the retained edge increases, the influence of the retained patches decreases and so the value of retained intact patches is expected to increase. The appropriate distance at which the habitat clump provisions should be applied will depend on how the harvested area is used by species (but see Kavanagh et al. 1995, Kavanagh and Webb 1998, Law et al. 1999, Kavanagh 2000, Law and Anderson 2000, Kavanagh and Stanton 2005).

The proposed approach allows the habitat clump provisions to be combined with the tree retention provisions. This is sensible as trees retained in clumps would be expected to have higher survival than isolated trees. However the proposed approach limits the number of trees that can be retained in clumps. While there can be some advantages in dispersing trees, generally the literature supports patch retention over dispersed retention. Therefore, in our view it is overly prescriptive to specify the number or proportion of the retained trees that can occur in clumps. If the prescriptions are clear regarding the best trees to be retained, it seems sensible that these trees can be retained as they occur across the landscape whether they are clumped or not.

The need for the habitat clumps to be permanent depends on the values in the clumps. If there are no values that take long time periods to form (e.g. hollow-bearing trees) then the need to keep the clumps in perpetuity is less important. However, the area available for harvest can potentially be impacted every five years. Five years may not be adequate for the understorey to recover from the previous disturbance. Therefore it is likely that retaining the clumps in the same area over time will be advantageous. If clump permanency is encouraged, a process needs to be established for identifying the clumps, and changing the location of the clumps if required (e.g. if the values are better captured in another location).

6.3.1 Key points

- The habitat clump outcome is quite general and does not appear to be targeting any particular features, other than representative localities within the harvested area. Little guidance is therefore provided on how to select these retained areas (e.g. whether to focus on older habitat, or areas with a denser understorey etc.).

- The current guidelines are quite prescriptive which limits the flexibility in how the habitat clumps can be modified to best suit local conditions.

- Depending on the ultimate objective of the habitat clump provisions and the ecology of the local species, it may be appropriate to allow aggregation of clumps.

- The proposed size of the clumps is very small, which will influence how well this licence condition achieves its objective.

7 Landscape connectivity

7.1 Proposed TSL condition

The proposed ‘outcome’ or objective for landscape connectivity in the revised TSL (EPA et al. 2013) is “a network of forest areas that are excluded from logging operations will extend across the State Forest Estate at a local and landscape scale to allow the movement, dispersal of threatened species and facilitate access to areas of refuge and allow for recolonisation of areas after harvesting

The licence concept is – Landscape connectivity will be provided through a network of undisturbed vegetation in riparian habitat corridors, and corridors of undisturbed vegetation adjoining different catchments through connecting ridge and headwaters.

This section provides information relevant to queries around the corridor width and edge effects and the value of additional patches to aid connectivity in certain areas.

7.2 Brief review of relevant information

Landscape connectivity is an important broad scale management strategy for biodiversity. Streamside reserves and corridors are common measures used around the world to promote connectivity between reserved areas, and retained patches may also contribute to connectivity (Koch et al. 2011). The efficacy of these measures will depend on a number of factors, including size and placement of retained areas within the landscape as well as target species (fauna or flora) and values (conservation or social acceptance).

Retained corridors or small patches of vegetation within a production forest landscape are susceptible to edge effects, such as physical damage (windthrow, burning) and changes in microclimate (air and soil temperature, humidity). Edge effects may have an impact on the effectiveness of retained areas. Aubry et al. (2009) reported that aggregates in the Pacific Northwest were susceptible to edge effects (elevated light and temperatures) which may compromise the ability of the retained areas to serve as sources for recolonisation of adjacent harvested areas. The study into retained patches and dispersed retention in the Pacific Northwest suggested that retention of large aggregates (>1 ha) or greater densities of dispersed retention (e.g. > 40 %) are needed to reduce the damage and subsequent mortality of retained live trees and provide habitat for sensitive taxa which are susceptible to edge effects, and that retention of >15 % were needed to ameliorate microclimate extremes (Aubry et al. 2009). These authors proposed a general strategy to ensure short term persistence of forest dependent species and public acceptance which included a combination of large aggregates (> 1 ha) and dispersed retention.

A study on the effectiveness of 100 m wide corridors of retained vegetation (wildlife habitat strips) between logged areas in Tasmania (Taylor 1991b) found that while the wildlife habitat strips had similar floristic species richness as larger intact reserves, they were subject to edge effects such as drying and loss of sensitive species. Similarly, Grove and Yaxley (2005) found that wildlife habitat strips may promote the survival of fauna, particularly carabids, that are usually associated with the edges of continuous forest, but wildlife habitat strips may be less effective habitat for species that associated with native forest interiors. The study by Grove and Yaxley (2005) implied that widening the wildlife habitat strips in Tasmania would benefit some interior forest species.

A review of the effectiveness of conservation measures in production forests in Tasmania, found that streamside reserves on mid catchment streams that are 30 m wide appear to protect habitat for most aquatic and terrestrial fauna studied, but even these reserves are entirely edge-effected for some terrestrial fauna like ground-dwelling beetles when the adjacent area is harvested (i.e. for at least five years after harvest) (Koch et al. 2012). Streamside reserves that are 40 m wide were, however, found to be effective in providing habitat for most terrestrial riparian species (Koch et al. 2012).

The effectiveness of retained areas to contribute to connectivity is largely unknown (Lindenmayer and Franklin 2002) and can vary depending on a number of factors, such as the size and placement of the retained areas, the heterogeneity of forest within the landscape and the target species or biodiversity value.

7.3 Comments on the proposed approach and response to queries

7.3.1 Should the corridor width be widened based on evidence for edge effects? Add patches on to widen?

The limited studies on the effectiveness of retained corridors has found that they maintain a similar assemblage of taxa compared to large reserved forest areas, but edge effects influence the presence of sensitive species and species usually found in the native forest interior. The wider the corridor the more chance there is of maintaining sensitive species and vegetation communities. However, widening existing corridors and riparian buffers may not be a practical solution due to conflicting wood production requirements. A combination of ridge and headwater buffers, dispersed retention through harvest areas and widening corridors through patch retention at sites where edge effects may be high. Options to meet the proposed ‘outcome’ for connectivity are provided for consideration in Table 12.

Table 12. Management options to meet the connectivity outcome – advantages and disadvantages.

Management	Advantage	Disadvantage	Comments
Maintain existing network of corridors.	Easy to implement. Easy to monitor the implementation of the corridors.	Edge effects may mean that outcome not met in full.	Monitoring is needed to determine if the corridors are achieving one or more of the stated outcomes.
Increase width of new ridge/headwater corridors to a minimum of 100 m where sensitive species are present (e.g. rainforest species).	Wider corridors are more likely to assist with maintaining habitat for species sensitive to edge effects. Easy to monitor the implementation of the corridors.	Reduced area available for timber harvesting.	Influence of edge effects are largely unknown for many taxa, increasing corridor width may not achieve the outcome. Monitoring is needed to determine if the corridors are achieving one or more of the stated outcomes.
Maintain existing network of corridors and a minimum level of dispersed retention.	May be easy to implement under current licences.	May reduce the area available for timber harvesting.	Monitoring is needed to determine if the corridors are achieving one or more of the stated outcomes.

8 Burning

8.1 Proposed TSL outcome

The proposed 'outcome' or objective for the burning condition in the revised TSL (EPA et al. 2013) is "Post harvest burning will be excluded from fire sensitive areas (to be specified, will include areas sensitive to damage from burning, e.g. rainforest, wetlands). Trees required for retention (Habitat, Recruit and feed) will not be damaged, killed or destroyed by post harvest burning."

This section provides information relevant to the question of how the licence conditions should promote avoiding burning sensitive areas Table 1.

8.2 Brief review of relevant information

Trees are retained on sites used for wood production for various reasons, such as providing habitat for fauna or providing a seed source for forest regeneration, and at various densities and spatial distributions. The use of a pre- or post-harvest burns to promote regeneration has the potential to directly and indirectly (e.g. windfall after burning, exposure to drying winds) impact on retained areas. Whether damage to retained patches or retained trees is acceptable will depend on the level of burn damage likely to occur (e.g. will the burn scorch or kill the tree or predispose the tree to fall through butt damage) and the objective of the retention (e.g. to maintain a late successional species/vegetation community).

Burning as a tool for regeneration following timber harvesting is used around the world in many different forest types. Balancing the primary objective of a regeneration burn (reduce fuel loads and promote regeneration) and other site objectives, such as maintaining remnant patches of forest or individual standing trees, is often challenging and depends on a number of factors including site conditions (topography, climate) and composition and dispersal of retained patches.

Whether it is acceptable to allow burn damage to retained areas will depend on the requirements of the species or vegetation communities within the retained areas.

8.2.1 Burning as a tool for management

Prescribed burning is used as tool to assist with species regeneration, habitat manipulation (e.g. increase food availability) and development of mosaics of burnt and unburnt areas. For example, it is argued that the contraction of high altitude grasslands and other treeless vegetation in north-east Tasmania is due to a loss of aboriginal fire regimes since European settlement and that prescribed burning should be implemented to maintain the values of the treeless ecosystems (Bowman et al. 2012).

Within wood production areas, burning may be used as a tool to maintain a certain species composition across the site. Shelterwood harvests with a prescribed fire are used to promote regeneration of high value oak species and supressed regeneration of yellow-poplar in the Piedmont region in Italy (Brose et al. 1999). Or burning may be considered compatible with the values of retained stands. Patchy burns in dry eucalypt forests in south-eastern Australia can provide habitat for colonising species (Penman et al. 2007) In the dry jarrah forest of western Australia a high intensity prescribed burn or wildfire is needed to achieve a broad scale regeneration of leguminous species (Shae et al. 2006).

Within the Tasmanian forest practices system, light (often patchy) burning of retained wildlife habitat clumps (retained patches of forest) is acceptable in selective harvesting operations.

'*Ensure WHCs are protected from harvesting activities and high intensity burns. Note that light top disposal burning activities within partially logged coupes or fuel reduction burning activities over a large area is acceptable provided, where possible, that the intensity of burning is minimised within WHCs'* (Forest Practices Board 2000).

8.2.2 Impacts of burning and avoiding harm to sensitive species or vegetation communities.

A regeneration burn following logging has the potential to negatively impact retained trees or patches both directly and indirectly. Burn damage can lead directly to tree mortality and changes in species composition. This can have follow on effects on flora and fauna habitat availability and food resources.

How prone retained trees and patches are to the regeneration burn will depend on a number of factors, including site conditions (topography, soil moisture, fuel loads) and composition and distribution of retained elements. In logged sites in south-eastern Australia, the mortality rate of retained trees was found to be higher on northerly aspects with low basal area retention (Gibbons et al. 2000).

Burning can be detrimental to sensitive species (such as late successional species) or vegetation communities within the retained areas. Methods to reduce the risk of burn damage to the retained patches in aggregated retention in Tasmania include raking fuels back from aggregates edges, ensuring heaps are not adjacent to retained patches and considering the season and conditions for burning (e.g. time of day, soil dryness, relative humidity, wind speed, hazard sticks and fuels) (Scott et al. 2011).

An example of a sensitive vegetation community which is carefully managed to reduce the risk of direct and indirect damage from logging and the regeneration burn is relict rainforest in Tasmania. Relict rainforest is closed forest which occurs outside the usual climatic range of rainforest. It usually occurs as small discrete patches, in fire-shadow sites amidst eucalypt forest (Neyland 1991). Patches of relict rainforest can support flora and fauna species of high conservation significance, such as the slender tree fern (*Cyathea cunninghamii*), or provide a food source for species reliant on particular plants.

Relict rainforest is prone to disturbance, including those associated with adjacent forestry operations. The impacts of disturbance on relict rainforest can be very long-lasting and include:

- Physical disturbance – disturbance to the canopy can result in changes to the microclimate (air and soil temperature, humidity) through increased exposure to sun and wind. A drier microclimate may eliminate some species, and increase the susceptibility of the stand to fire.
- Fire – an intensive fire can result in the rainforest stand being replaced by wet eucalypt forest, low intensity fires can alter the microclimate resulting in effects described above.

Management actions implemented in Tasmania to reduce the direct or indirect impacts of forestry on relict rainforest patches include:

- Buffers – minimum 40 metres width (horizontal distance). Extended to 80 metres if requires for adequate protection (e.g. rainforest located on a ridgeline should be buffered by 80 metres on the northwest margin where there is more chance of exposure to drying winds and fire).
- No physical disturbance – no felling of trees or hauling of logs into or out of rainforest or rainforest buffer.

- Fire excluded – Careful pre-logging planning should take place to ensure that the coupe boundary shape is compatible with achieving a successfully contained regeneration burn. Prescriptions such as ensuring burning in appropriate conditions such that fire will move away from the rainforest patch (largely to prevent escape and scorch effects) may need to be included. Additional or wider mineral earth fire breaks may be appropriate in some circumstances. Pulling logging slash and debris away from the coupe boundary may assist in minimising scorch effects. Where practical, windrows should not be placed parallel to the reserved coupe boundary and/or located as far as possible from the coupe boundary.

8.3 Comments on the proposed approach and response to queries

The outcome to 'not damage' trees retained as habitat, recruitment and feed trees may be impractical to implement if the site requires a burn after harvesting to promote eucalypt regeneration. Allowing a cool/light burn within areas supporting scattered retained trees may not result in a negative impact, and in some case the burn may have an ecological benefit. In areas where direct or indirect impacts from regeneration burns is considered harmful strategies to minimise the risk of fire entering sensitive areas include buffers of retained vegetation (depending on topography), pulling fuel loads back from the edges of retained areas and considering the timing and conditions of the regeneration burn.

9 Species not adequately covered by general licence conditions

The area covered by the coastal IFOAs (Figure 1) is known to support approximately 683 terrestrial threatened species (460 threatened plant species 109 threatened bird species, 62 threatened mammal species, 26 threatened frog species, 17 threatened reptile species and 9 threatened terrestrial invertebrates) (M. Pennay, pers. comm.). The goal of the Threatened Species Licence is primarily to mitigate impacts on these threatened terrestrial species (NSWEPA 2013). Threatened aquatic species also occur in the area but their requirements are to be met through the other licence conditions.

The current TSL prescribes targeted surveys for individual species and only implements management prescriptions if a species is detected. This 'survey and manage' requirement, and the associated training, has significantly increased the understanding and knowledge of the occurrence of threatened plant and animal species (Lemckert and Cameron 2004). However, the effectiveness of the 'survey and manage' approach is largely unknown, probably because the time and cost involved in the pre-harvest surveys has meant that there has been little effectiveness monitoring. Some reported perverse outcomes of this prescriptive 'survey and manage' approach include redundant surveys carried out in unsuitable habitat and records of threatened species surveys required in areas that already have prescriptions in the form of standard exclusions zones (Meek 2004).

While the majority of protective measures in the current TSL involve buffers being established around records of individuals or small populations, landscape-scale measures have been adopted in recent years which will contribute to threatened species management. Some of the landscape measures adopted include the retention of important areas, including large tracts of interconnecting habitat for target species (e.g. owl habitat) (Kavanagh 2002), wildlife corridors, rainforest and old growth exclusion areas. The aim of these landscape-scale measures is to conserve populations and communities rather than individuals, and such measures have been recommended as a future direction for NSW forest management (Kavanagh 2002, Law 2004, Meek 2004).

The revised TSL approach has less reliance on pre-harvest surveys and more of an emphasis on landscape-scale conditions, which is consistent with the approach recommended in the literature (Lindenmayer and Franklin 2002, Kavanagh 2002, Law 2004, Meek 2004). The available evidence indicates that the TSL general licence conditions (e.g. local landscape conditions, tree retention and habitat clumps conditions) should contribute to the maintenance of habitat for threatened species by avoiding and/or minimising the scale of threats/ threatening processes (e.g. loss of hollow trees, habitat loss, disturbance and fragmentation).

The TSL general licence conditions alone, however, may not always completely cater for species with specialised requirements (e.g. particular structural or floristic features) (Kavanagh et al. 2004). A clear and transparent process for developing the species-specific management conditions needs to be developed involving all stakeholders and a scientific advisory group. A first step would be a review of information on the species ecology, distribution and threats. How the TSL general licence conditions contribute to the management of threats to each species, and any requirement for additional measures, could then be assessed. Measures for such species may include targeted retention of a network of habitat across the landscape known to be preferred by the species or identification and protection of local habitat features important for breeding.

Table 13 illustrates the approach that might be taken when reviewing management of particular threatened species. The results of this approach could be used to develop additional management actions required, and will facilitate effectiveness monitoring.

Table 13. Evaluation of the contribution of the revised TSL general conditions to the conservation of threatened species.

Note. The information in this Table is an example of a process that could be used to determine the extent to which the revised Threatened Species Licence conditions may contribute to the conservation requirements of threatened species. This is not intended to be a comprehensive review. The species highlighted as examples of a functional group may have other ecological or management requirements which are unknown to the authors.

Functional group/ species	**Rational**	**Current terms of licence under the *Threatened Species Conservation Act 1995***	**Recommendation**	**Revised TSL licence conditions which may contribute**
Species with a wide distribution and/or broad habitat requirements. An example may be *Asperula asthenes*	Species with a wide distribution and/or found in a range of habitat types may be relatively tolerant of the current or historical disturbance regime.	E.g. Lower North East Threatened plants to which condition 6.23 must be applied that are not currently known, or not considered likely to occur, in areas of the SFNSW estate outside statutory reserves. Condition 6.23 Where there is a record of any of the species listed within the compartment or within 20 metres outside the boundary of the compartment, the following must apply: a) An exclusion zone of at least 20 metres radius must be implemented around all individuals. b) An exclusion zone of at least 20 metres wide must be implemented around all groups of individuals. A group is defined as more than one individual located less than 20 metres apart.	Consider: management through revised threatened species licence conditions. General licence conditions may capture potential habitat for species with a wide distribution and broad habitat requirements. Species associated with particular site conditions (e.g. flood zones of rivers) may be adequately managed through other licence conditions which protect waterways (e.g. landscape connectivity).	General licence conditions (thresholds for area retention). Threatened ecological communities Habitat clumps Landscape connectivity
Narrow distribution, disturbance dependant	Species may require disturbance (e.g. fire or mechanical disturbance of seed	E.g. Upper North East Threatened plants to which condition 6.26 must be applied that are known to occur, or	Consider: site/species specific management for ecological requirements of the species.	Burning Habitat clumps

Functional group/ species	**Rational**	**Current terms of licence under the *Threatened Species Conservation Act 1995***	**Recommendation**	**Revised TSL licence conditions which may contribute**
species An example may be *Acacia chrysotricha*	bed) to regenerate. Specific disturbance regime required. Too frequent disturbance may lead to a decline in the population. No replacement of adult plants may lead to a gradual exhaustion of the soil-borne seed bank. A long time between disturbance events may result in a decline in population as the species is outcompeted by other plants.	considered likely to occur, in areas of the SFNSW estate outside of statutory reserves. Condition 6.26 Where there is a record of any of the species within the compartment, the following must apply: a) A minimum of 90% of individuals must be protected from specified forestry activities. During harvesting operations, the potential for damage to these plants must be minimised by utilising techniques of directional felling.	The disturbances associated with timber harvesting (e.g. cool/light regeneration burn) may be compatible with the regeneration requirements for the species. Consider utilising forestry as a management tool for maintaining the species on site. For example, allow 50% of the on-site population to be burnt by the regeneration burn if the disturbance is within the required regime for the species (e.g. every 25–60 years for *Acacia chrysotricha*), and maintain 50% in excluded areas ensuring that adult and seedlings are captured within the excluded areas.	
Narrow or disjunct distribution, specific site requirements, small/declining population, disturbance	For these species loss of known sites, loss of known or potential habitat and disturbances (e.g. fire) will lead to population declines.	E.g. Lower North East Threatened and protected plants to which condition 6.23 must be applied that are known to occur, or considered likely to occur, in areas of the SFNSW estate outside of statutory reserves.	Consider: Appropriate exclusion zones based on the ecology of the species and the site conditions (e.g. topography). For example, if the species is dependent on the stable	Species likely to require additional consideration beyond TSL general licence conditions (although other conditions may assist with species management).

Functional group/ species	**Rational**	**Current terms of licence under the *Threatened Species Conservation Act 1995***	**Recommendation**	**Revised TSL licence conditions which may contribute**
intolerant An example may be *Hicksbeachia pinnatifolia*		Condition 6.23 Where there is a record of any of the species listed …. within the compartment or within 20 metres outside the boundary of the compartment, the following must apply: a) An exclusion zone of at least 20 metres radius must be implemented around all individuals. b) An exclusion zone of at least 20 metres wide must be implemented around all groups of individuals.	microclimate of a rainforest at the bottom of a slope, additional protection may be required upslope to reduce the indirect impacts such as exposure to drying winds.	

10 Monitoring, enforcement and adapting management

10.1 Proposed TSL condition

The following monitoring outcome is proposed for the revised TSL (EPA et al. 2013) – 'The effectiveness of the conditions to achieve the outcomes expressed in the licence will be monitored. The results of the monitoring will be used to continually improve the effectiveness of the licence.'

10.2 Is the approach appropriate for implementation and effectiveness monitoring?

While monitoring is a condition in the draft licence document, reference to protocols and supplementary guidance material in the TSL would help ensure the monitoring is undertaken in an effective manner. There also needs to be reference to the process that will be followed to ensure a commitment by all stakeholders to continual improvement. Monitoring to evaluate both the implementation and effectiveness of the revised approach and a commitment by all stakeholders to adaptive management (the potential for changing 'goal posts') is essential if an outcome-based forest management system is to work and remain acceptable to the broader community. Many of the issues relating to public acceptance that have arisen elsewhere, where an outcome-based approach has been adopted, have resulted from the lack of evidence regarding the effectiveness of a particular approach (Marshall 2006, McMillan and Warttig 2007, Munks et al. 2010). The need to demonstrate a commitment to forest stewardship (social licence to operate) and continual improvement is increasingly a market-based requirement. A requirement for monitoring in legislation and security in funding is essential to demonstrate commitment to the continual improvement component of an outcome-based system by government.

To facilitate monitoring (both implementation and effectiveness), it is important that the 'outcomes' are clear and measurable. If an outcome-based approach is to be successful then the intended 'outcome' or objective needs to be clear and measurable to those tasked with the job of implementing and monitoring (and auditing) the actions taken to meet the outcome. It is recommended that the current outcomes in the draft IFOA agreement paper on the Threatened Species Licence (EPA et al. 2013) are reworded taking into account the SMART model (Doran 1981).

10.2.1 Structure of objectives (outcomes)

General, high level conservation objectives are useful in providing some overarching guidance for conservation management but have limited use when dealing with specific management issues and compliance monitoring. High level objectives tend to be theoretical and include outcomes such as 'maintain or improve' local populations or 'manage for' connectivity between reserves, and provide little practical guidance on how to achieve the outcome on the ground. In order to address specific conservation management issues measurable sub-objectives need to be developed taking into account the management questions. For example, if the high level objective is ‘to maintain or improve the availability of a food resource for species x’, then sub-objectives need to be developed taking into account questions such as: Where and how should feed trees be retained to maximise the benefit to the species? Should they be retained at a consistent rate across the landscape? Or should the conservation effort be focused on specific areas, or forest patches? To be effective the sub-objectives need to take into account the realistic and practical trade-off between conservation and economic activity.

Once a high level objective is broken down into targeted sub-objectives, management actions can be developed to achieve the sub-objective and therefore the overarching objective. In the absence of scientific data, the link between sub-objectives and the higher-level objective may be theoretical. Table 2 illustrates an example of high-level objectives, sub-objectives and management actions (conditions) for the New South Wales IFOA context. The process of linking objectives, sub-objectives and management actions can assist conservation managers to determine what is already being achieved and where the gaps are.

Management objectives used in the forest management systems in Australia and overseas vary considerably in their usefulness from a practical implementation and monitoring perspective (Koch et al. 2011). For outcome-based forest management approaches the SMART model (specific, measurable, achievable and aligned, resourced, and timed) (Doran 1981) has been found to be the most useful in the development of objectives.

Criteria for a SMART objective are:

- Specific – clearly state the intent of the objective.
- Measurable – ensure the effectiveness of the objective can be monitored and assessed.
- Achievable and aligned – it is important that objectives can realistically be achieved and within the legislative and legal framework of the environment in which they are set.
- Resourced– state what results can realistically be achieved, given available resources.
- Timed – specify a timeframe for when the results can be achieved.

A critical component of a SMART objective is that it is measurable, facilitating adaptive management. It is important to consider monitoring when designing the objectives (outcomes), rather than try to design a monitoring program for a particular outcome retrospectively.

10.3 Development and implementation of a monitoring program.

A review of effectiveness monitoring approaches both in Australia and overseas (Munks et al. 2010, Munks and Koch 2011) found that the desirable features are:

1. A governance structure involving all stakeholders (independent monitoring committee).
2. A clear alignment with management objectives (outcomes, targets and reporting requirements.

3. The type of monitoring is tailored to the clarity and scale of the objectives.
4. A ranking method to prioritise monitoring.
5. A range of integrated effectiveness monitoring projects with designs that take into account the above considerations. Use of habitat surrogates and modelling.
6. A complementary state-level trend monitoring program involving biodiversity and land management agencies (forest management agencies).
7. Identification of complementary research needs.
8. An agreed process for reporting, feedback and communication to forest managers and other stakeholders.
9. Connections to the management decision process early in the development of a program.

An effectiveness monitoring program for the revised TSL could be divided into two main areas – monitoring of conditions designed for general biodiversity and monitoring of conditions developed for particular threatened species. The general approach would involve establishing clear objectives, linking threats with management actions, determining monitoring priorities, designing monitoring projects, seeking funding and then implementation and reporting.

It isn't possible to monitor everything everywhere at every spatial scale. Monitoring is expensive and time is generally limited so what to monitor needs to be prioritised in a manner that is transparent and comprehensive. This can be done by assessing each licence outcome in terms of:

1) the expected proportion of the area, or proportion of harvest plans, to which this management issue applies (significance),
2) the expected effectiveness of the management action in meeting the outcome,
3) the degree of relative certainty/uncertainty about whether the management action is effective, and
4) the effort to conduct the proposed monitoring (Table 14).

The monitoring projects can then be sorted by proportion of operations affected (high to low), effort to monitor (lowest to highest), the degree of uncertainty that management is effective (highest to lowest) and management effectiveness (lowest to highest). The result will be a list of the highest priority projects.

The type of monitoring used needs to be flexible to take into account the inherent complexity of monitoring wildlife and the variety of biodiversity management practices to be evaluated. Many types of activities can be labelled as monitoring, ranging in complexity from the very simple (basic measurements repeated at set intervals over time) to highly complex (research projects). The common element is that any monitoring project must concern itself with the temporal dimension. Usually this is taken to involve repeat measurements over time, but retrospective research ('space-for-time') can also be used to provide answers in a much shorter time-frame.

Resources need to be allocated to data analysis, storage and display (ideally on websites), and to communication and customised reporting of results for all stakeholders. Data transparency is a key component of the process. For continual improvement to occur there is a need for all to know and understand the science and state of knowledge.

Table 14. An example of how a management objective could be assessed in a process for prioritising monitoring efforts.

Licence objective	Research or monitoring objective	Proposed monitoring approach	Proportion affected	Management effectiveness	Uncertainty management is effective	Effort to monitor
Tree retention: Enhance opportunities for recolonisation of disturbed areas	Determine how use by fauna of retained trees changes over time	Surveys of birds, and mammals (especially hollow-users) in harvested landscapes to determine areas used.	Medium	High	Medium	High

11 Conclusions

Policy and management responses with respect to the conservation of threatened species have traditionally focused on single species. However, it has been recognised for a while that this is not efficient or sustainable in the long-term, particularly in areas outside of formal reserves, and a multi-species landscape-scale approach may be more effective. The revised TSL, proposed as part of the IFOA re-make, with a greater emphasis on outcomes to increase the resilience of biodiversity (including threatened species) at the landscape scale, in areas utilised for wood production, is consistent with this approach.

While the revised licence conditions (EPA et al. 2013) should contribute to achieving the overarching goals and sub-objectives for conservation of forest biodiversity in areas outside of reserves established in the literature (Table 2), there are some gaps that need consideration. These include conditions for post-harvest regeneration of habitat, design and management of the road network and stream crossings, hydrological processes, management of pests, disease and genetic pollution, forest remnants, maintenance of soil fertility and structure, harvest dispersal in time and space. Some of these, however, may be covered by conditions in the environmental protection licence (EPL) and the fisheries licence (FL) and therefore do not necessarily need to be included in the TSL. The information in the literature suggests that by following the general principles of landscape management for biodiversity in areas utilised for wood production, many of the threats to native species should be ameliorated. However, as recognised in the remake discussion paper (NSWEPA 2013) these measures alone may not be adequate for some particularly sensitive species (Kavanagh et al. 2004).

While the move to a more outcome-based approach with less emphasis on pre-harvest species surveys is considered positive, it is difficult to comment on whether or not the changes to the TSL approach will meet the ‘no erosion of environmental values’ objective of the IFOA re-make from a threatened species perspective. This is because of the lack of knowledge of the effectiveness of the current TSL conditions and the inherent uncertainty around the effectiveness of the proposed revised licence conditions, most of which is based on theory. Areas identified in this review as potentially needing further work are the measures for dispersing harvesting (in particular the maximum harvesting threshold), the size of the habitat clumps and ways to minimise edge effects. Monitoring, reporting and a commitment to continual improvement are critical for the success and public acceptance of this revised TSL approach. An important next step in the IFOA re-make process should be the design of a monitoring program. Outcomes for implementation and effectiveness monitoring, funding, reporting and a process for continual improvement should be included as part of the licence conditions.

The difficulties with balancing and prioritising the need for management to be ecologically meaningful, practical to implement and easy to audit were highlighted in this review. Over-arching principles are required, that integrate the objectives of all of the Acts relating to IFOAs, to provide guidance on the contribution conditions delivered through IFOAs are expected to make to the conservation of threatened species and environmental values in general. Desired outcomes need to be clear, practical and measurable. Comprehensive guidance material and training of those responsible for implementing actions and auditing will help to ensure the success of the revised approach.

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Appendix A. Contract Brief

Review of proposed approach for biodiversity conservation in NSW State Forests through an IFOA.

12.1 Background

The NSW project team has prepared a first stage agreement for the management of threatened species and biodiversity values in NSW State forests as part of an Integrated Forest Operations Approval. A broad framework for the management of habitat for a broad suite of species, including threatened species has been agreed with stakeholders and a paper is being prepared for public consultation. The NSW project team has approached the FPA for a review of the proposed approach and advice on the details. In particular on the management actions and monitoring program (effectiveness, implementation or enforceability perspective) still under development.

12.2 Project Scope

1. The NSW project team will provide the FPA with a draft (proposed) approach for the conservation of a broad suite of forest dependent threatened species, in State Forests in NSW through an Integrated Forestry Operations Approval. This will include a NSW based meeting between the NSW project team and the FPA. This meeting will include a field visit to give the FPA an idea of the types of operations conducted and operational issues.

2. The FPA will undertake an initial review of the proposed approach and provide advice and recommendations on some specific areas relating to threatened species and biodiversity conservation in production forest areas identified by the project team.

3. The FPA will provide more detailed advice on specific management actions and prescriptions proposed to meet threatened species and biodiversity management objectives. The FPA will also provide information on any alternative actions/prescriptions that could be adapted for NSW to effectively manage logging impacts at both landscape (regional) and local scales. These advice and recommendations are to be made with;

    a. Consideration of the key general/ broader* impacts to threatened species from forestry operations associated with

        i. loss of hollow bearing trees, feed trees, and coarse woody debris,
        ii. habitat fragmentation and disturbance, and
        iii. direct and indirect impacts on aquatic ecosystems (eg wetlands, waterways).

*(acknowledging that some impacts are species or site specific and these will be dealt with individually where appropriate through a separate consideration)

and

  b. Consideration of the operational and environmental effectiveness of approaches taken in Tasmania (and other Australian Native forests where appropriate) to conserve threatened species and biodiversity under codes of practice.

1. Provide informal advice to the project team on questions to clarify any issues and considerations raised above.
2. Provide a draft report by 13th December 2013 and following consultation with the project team provide a Final report by 3rd March 2014.

Note: The NSW project team will provide FPA with background information on the current NSW licence conditions, threatened species and approaches used in the current framework, and clarification or supporting information as needed.

12.3 Project outputs and milestones

- The FPA will provide the NSW project team with a report covering a review of the proposed approach (1) and recommendations on specific areas identified by the NSW team (2 and 3).

- Milestone 1 - A short draft report covering the first preliminary stage of the review (1 and 2) will be provided to the review team by the 13th Dec 2013.

- Milestone 2 - Final report with a more in-depth review and advice on specific management actions and prescriptions will be provided by the 3rd March 2014.

Appendix B Preliminary report summary

(Munks et al. 2014)

- This report was prepared by the Tasmanian Forest Practices Authority for the NSW Environment Protection Authority, Forestry Corporation and DPI (Fisheries). It provides preliminary comment and recommendations on the proposed conditions in the TSL draft agreement paper (EPA et al. 2013)(Milestone 1 of the contract brief, Appendix A).

- General comments are provided on the proposed approach. While the shift from complex, prescriptive, site-specific licence conditions to more outcome-based, landscape-scale provisions is considered positive, the need for systems to facilitate implementation, monitoring and adaptive management is raised.

- The importance of providing clear, outcomes-based objectives that can be flexible in their application is discussed. It is recommended that the objectives (outcomes) provided in the draft TSL are reviewed.

- The licence conditions of the TSL are commented on individually. The value of the proposed licence conditions, and the intent and wording of the proposed outcomes and licence conditions are discussed. Recommendations are made in relation to each of the proposed licence conditions. These recommendations aim to simplifying and clarify the approach, to ensure the desired outcomes are achieved. Several management issues not addressed in the current TSL are raised for consideration.

- **Summary of recommendations**

Topic	**Recommended actions**
General comments on the proposed TSL	1. Consider changing the title of the licence conditions from ‘threatened species licence’ to ‘biodiversity licence’. 2. Re-structure the licence, with conditions that relate to the broad landscape-scale first and conditions for impacts at the local scale second. Consider adding a separate outcome/licence condition for impacts on freshwater systems. See suggested re-structure in. 3. Consider amalgamating some licence conditions where the desired outcome is similar (e.g. the outcome for the ‘landscape connectivity conditions’ and the ‘conditions for the protection of threatened species habitat at the broad landscape scale’). The outcomes could be reworded as ‘Goals’, followed by a series of management targets to meet the goal and then recommended actions delivered through planning tools, see (FPA 2013). 4. The EPA should consider taking an active role in promoting best practice through the development of ‘user-friendly’ planning tools/guidelines and an EPA co-ordinated training program and advisory service for forest managers and foresters.

Topic	**Recommended actions**
	5. Planning tools and guidelines should be referred to in the TSL. Management actions likely to change may be delivered through planning tools that hang off the licence. Have a two-tier approach with some tools that are just informative, and some that are mandatory. Develop a clear process for the updating of such planning tools to promote adaptive management. 6. An advisory process should be developed to facilitate advice on 'alternative approaches' when the prescribed management targets/actions cannot be met. This will enable a clear and transparent decision-making process if management approaches are challenged by the broader community. 7. Develop an MOU with DPI Fisheries to cover an agreed management approach or procedures relating to the regulation of fisheries and threatened species licence conditions via the EPA. This will further streamline the bureaucratic process so that one agency is primarily responsible with referrals to the DPI Fisheries when required. 8. A monitoring program should be designed and the key elements included as part of the licence conditions. It should include 'desired outcomes' for implementation and effectiveness monitoring and should include a funding commitment and a commitment to adaptive management (the potential for changing 'goal posts). 9. A commitment from industry and government to support monitoring and adaptive management should be sought. Funding previously used for pre-harvest surveys could be redirected into monitoring.
General comments on Outcomes	1. Review outcomes (objectives) in the IFOA and TSL and ensure they are clear, quantitative, outcomes based, appropriate for forestry planning, and flexible in how they might be applied. 2. Avoid conflicting outcomes and consider amalgamating where overlap (eg., outcome for single tree retention and habitat clumps) 3. Definitions of terms used in the outcomes should be provided in the TSL document. 4. Since the appropriate type of monitoring depends on the clarity and scale of the objectives this should be taken into account when reviewing the outcomes.
Conditions for impacts at the local landscape scale	1. Review wording of the outcome. 2. Clarify the intent of the licence conditions. 3. For licence condition 1 clarify how areas are to be selected for retention, and how management might differ depending on the values that are or are not retained. 4. Clarify how the minimum habitat retention guidelines fit in with threatened species management. 5. Review definition for local landscape. 6. Consider catchment management when establishing maximum

Topic	Recommended actions
	harvesting thresholds. 7. Consider managing for stand age structure more explicitly. 8. Establish record-keeping procedure for the selection and location of retained areas. 9. The requirement to regenerate the forest following harvest does not appear to be emphasised in this licence concept? This is surprising as successful regeneration of a harvested area back to its pre-harvest state is a fundamental to the principle of ecologically sustainable forest management. A statement about use of appropriate silvicultural methods, ensuring adequate regeneration, should be included as part of this licence condition.
Threatened ecological communities	1. Reword the outcome to clarify the intent of the TEC licence. 2. Consider rewording the outcome to allow for recognition that some forms of forestry may be compatible with maintaining the specific values of a TEC. 3. Consider indirect impacts (e.g. burning adjacent to a TEC) 4. Develop an on-ground assessment process (as part of harvest planning) for identifying TECs in the absence of fine-scale accurate habitat mapping. 5. Develop a process for updating TEC maps from survey data. 6. Develop a transparent process for determining when or under what conditions TECs may be impacted through an ecological harvest plan. 7. Define the vegetation communities, and provide the forest industry with a key to identifying each TEC and supporting training courses.
Tree retention	1. Review wording of the outcome. 2. Consider taking an area-based landscape approach to management of mature trees. 3. If taking a single-tree retention approach, review the literature on fauna requirements in different forest types and be transparent in how a decision on what, and how much is retained, is reached. 4. Review wording of licence conditions to emphasise the desired outcome and be less prescriptive. 5. Develop definitions and identification tools. 6. Ensure the approach taken will help provide habitat over the long term, and is compatible with the different types of silviculture used.
Giant trees	1. Clarify why giant trees are to be retained (eg., cultural/social value?) 2. Review definition of giant trees
Habitat clumps	3. Clarify the wording/intent of the stated outcome. 4. Alter the licence prescriptions to be less prescriptive and more flexible to cater for local conditions. 5. Consider amalgamating the habitat clump requirements with the retained tree requirements, or taking a more landscape approach to

Topic	Recommended actions
	habitat retention.
Landscape connectivity	1. Consider simplifying the wording of the outcome. 2. Develop a process for identifying the different topographies within the existing network of retained corridors to determine if a range of habitat types and topographies are being captured for landscape connectivity. 3. Consider the practicality of a catchment based stream classification system. 4. Consider providing more guidance around the desired width and spatial distribution of corridors.
Burning	1. Consider the intent of the burning licence and the practicality of meeting the burning licence conditions in terms of achieving regeneration and managing the biodiversity values. 2. Consider the need for prescribed buffers between the burning boundary and a sensitive TEC.
Conditions for the protection of threatened species at a broad landscape scale	1. Amalgamate with the 'landscape' connectivity section and move to earlier in the document 2. Reference relevant planning guidelines
Key threatening processes	1. Review wording of the outcome taking into account the above comments. 2. Consider including this section earlier in the licence structure
Species not adequately protected by the general licence conditions	1. Remove the term 'harm' from the outcome. It is too ambiguous. Suggest the wording 'maintain viable populations' to replace 'mitigate harm'. 2. Define what 'mitigate negative impacts' is being applied to. For example 'mitigate negative impacts to species populations within areas subject to forestry operations.' 3. Develop a clear and transparent process to determine which (and to what extent) species are adequately managed through general licence conditions, which species require additional management conditions and a process for adaptive management (based on results of monitoring and/or research). 4. Develop a process to deliver information to practitioners in a clear and user-friendly way. 5. If this threatened species licence is required to manage potential habitat (as well as known locations/populations) for threatened species, additional information will be required such as range maps and habitat

Topic	Recommended actions
	descriptions (for an example see http://www.fpa.tas.gov.au/fpa_services/planning_assistance/advisory_planning_tools/Biodiversity_values_database
Monitoring and process to adapt licence conditions/management	1. Clarify wording of the outcome. 2. Undertake a prioritisation process to identify monitoring projects to be undertaken (for an example see (FPA 2012)). 3. Develop an agreed monitoring program and refer to in the licence conditions 4. Clarify the parties responsible for funding and implementing the monitoring program. 5. Clarify the adaptive management process and mention in the licence conditions.

Appendix C. Summary of field visit

(21st–23rd February)

Attendees – Michael Pennay, Paul Campbell, Dean Kearney, Doug Binns, Peter Walsh, Justin Williams, Amy Koch, Sarah Munks

Day 1 – Wedding Bells and Conglomerate State Forest

Visited two sites in the regrowth zone. The first was an intensively harvested regrowth stand of blackbutt, second at a riparian reserve. Issues relating to the local landscape conditions were discussed including retention rates and spatial arrangement. Flexibility and enforcement were also discussed.

Day 2 – Marengo and Clouds Creek State Forest

Visited three sites. The first site was forest in New England Blackbutt and mixed tablelands species forests in Marengo State Forest, the second site was Tallowwood, Sydney Blue Gum, moist coastal hardwood forests at Clouds Creek State Forest. The third site was mixed dry coastal eucalypts (Ironbark, white mahogany, spotted gum, red gum) at Clouds Creek State Forest.Issues relating to tree retention and clump conditions were discussed. Planning and reporting and how to deal with flexibility in the current IFOA context were discussed.

Day 3 - Sydney meetings with M Pennay and J Williams and P Campbell. Presentation on the Tasmanian forest practices system and some new initiatives for landscape planning of biodiversity values.